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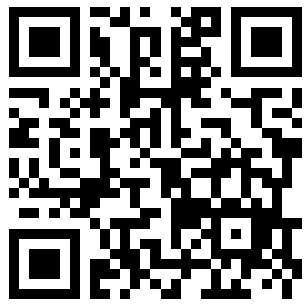
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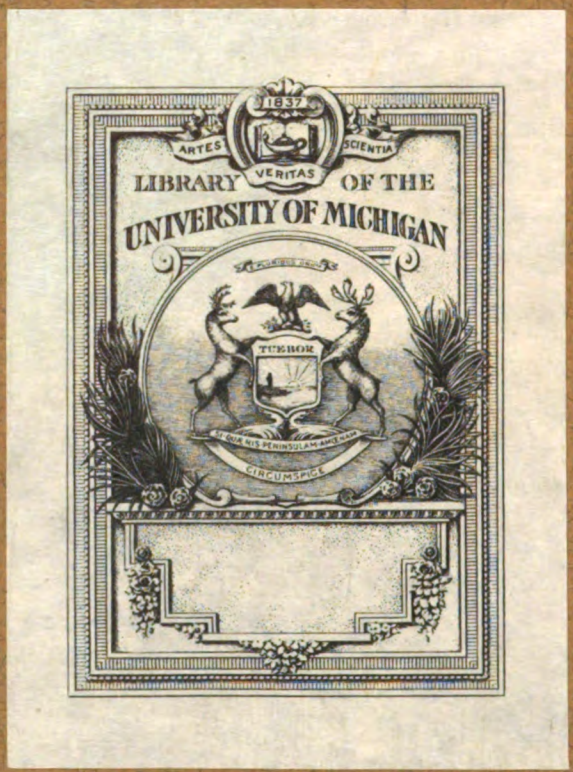
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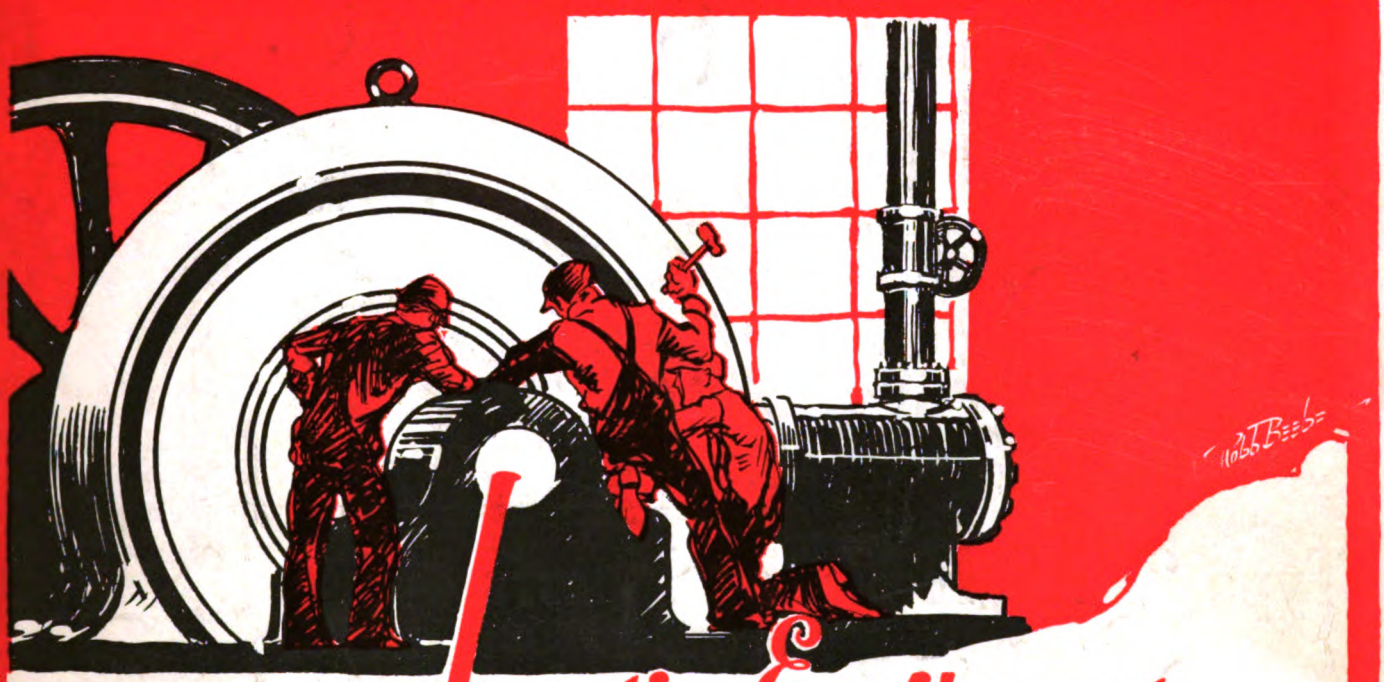
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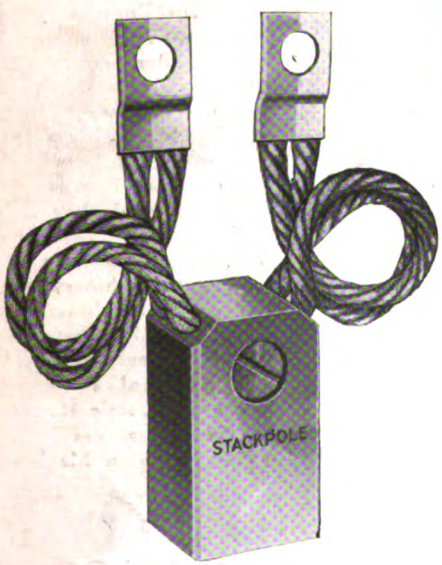
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Inactive Equipment the bugbear of production



Of course, machine trouble may be caused by anyone of a dozen reasons such as faulty design, worn bearings, open circuits, unbalanced armature, and the like.

BUT—with a Stackpole Carbon Brush one common cause of machine failures will be eliminated.

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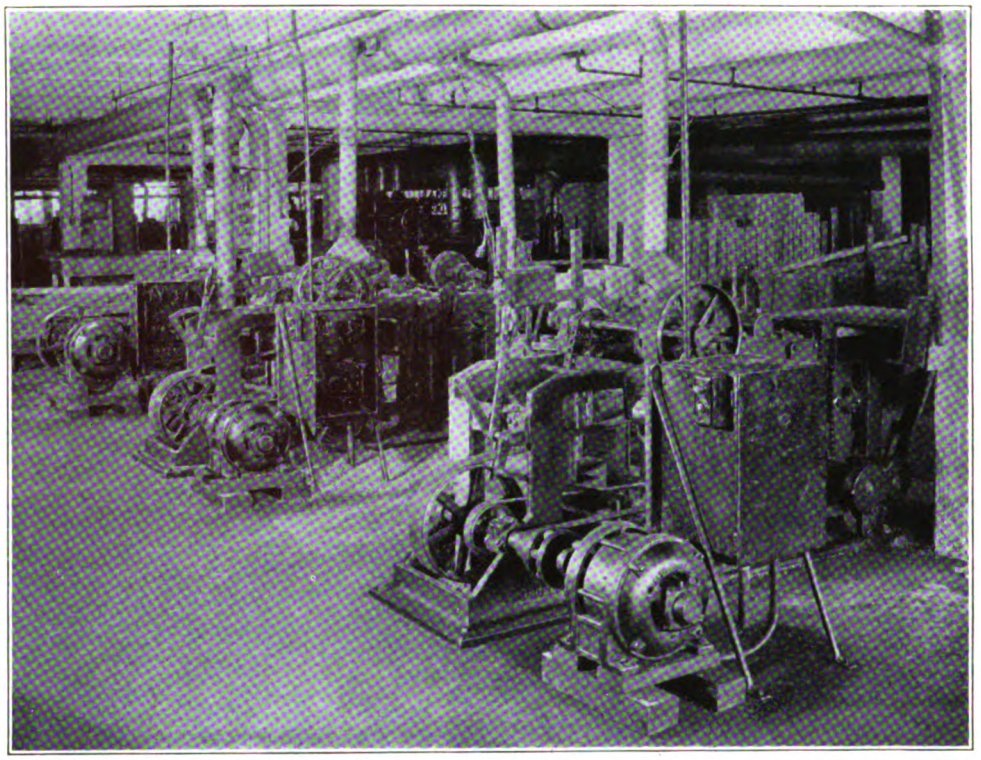
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ALLIS-CHALMERS



Type "AR" Induction Motors
drive
Woodworking Machinery

Above is shown Type AR Squirrel Cage Motors driving Sash Stickers in the plant of the Watsontown Door & Sash Co., Watsontown, Pa.

These motors are exceedingly rugged due to their all-steel frame construction. Their particular design makes for very thorough ventilation and a very accessible motor for cleaning.

Allis-Chalmers power equipment is used almost exclusively in this plant.

PRODUCTS:

Electrical Machinery
Steam Engines
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Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 83 Chicago, January, 1925 *Number 1*

Make a Work-Done Inventory Covering 1924—

Check Up on Yourself, Your Plans and the Results That You Aimed at During the Past Year



THE beginning of a new year is a good time to sit down in some quiet place and make a list of our mistakes, disappointments and failures to accomplish the things we thought we were going to do during 1924. Such a frank analysis of ourselves and our work will point out the reasons for not being as far ahead in our plans as we thought we would be at this time, and in most cases show that the reasons therefor lie at our own doorstep.

Here are some questions that you should be able to answer:

1—Did you write out a plan and detail the things that you planned to do during 1924?

2—If so, can you show that the things accomplished will lead to greater results this year?

3—Have you analyzed the weak spots in your 1924 plan and know where and how to revise them so as to get the results you know are possible?

4—Are you making your plans known to your fellow-associates and getting their co-operation and enthusiastic support?

5—Is your lost-time (delay time) production less than last year?

6—Is there less or more equipment in the shop for repairs at this moment than there was last year, and is this due to better application and maintenance on the part of the organization that you control?

7—Have you investigated new and better methods for installing, repairing and maintaining your equipment? The world does not stand still—why should you?

8—Are plant operations any more efficient due to your efforts?

9—Did you save anything for the plant last year? If so, do you know how much?

10—Are your men happier and more interested in their work than formerly? Have you realized that it is your job to bring about this state of affairs?

11—Have you had to fire less men during 1924 than in 1923? If so, was it through improved methods that you devised for handling work or in selecting the men?

12—Have you made "the old man" feel that you are indispensable to his organization and one who can not be replaced very quickly?

13—Are you studying the work and results of other men holding positions like your own?

14—Have you asked INDUSTRIAL ENGINEER to help you get the information you need but find hard to locate when working out your problems? This is one good place to go when checking up on the practical ways that others have adopted to get their results.

Your answers to these questions will give you a real analysis of yourself and your work. If you adopt the practice of making a plan and then working that plan, your boss would be interested in a report embodying these questions, or similar ones, and their answers. Try it out.

Practical Pete

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Three Large Manufacturing Units Created by Growth of the Electrical Industry

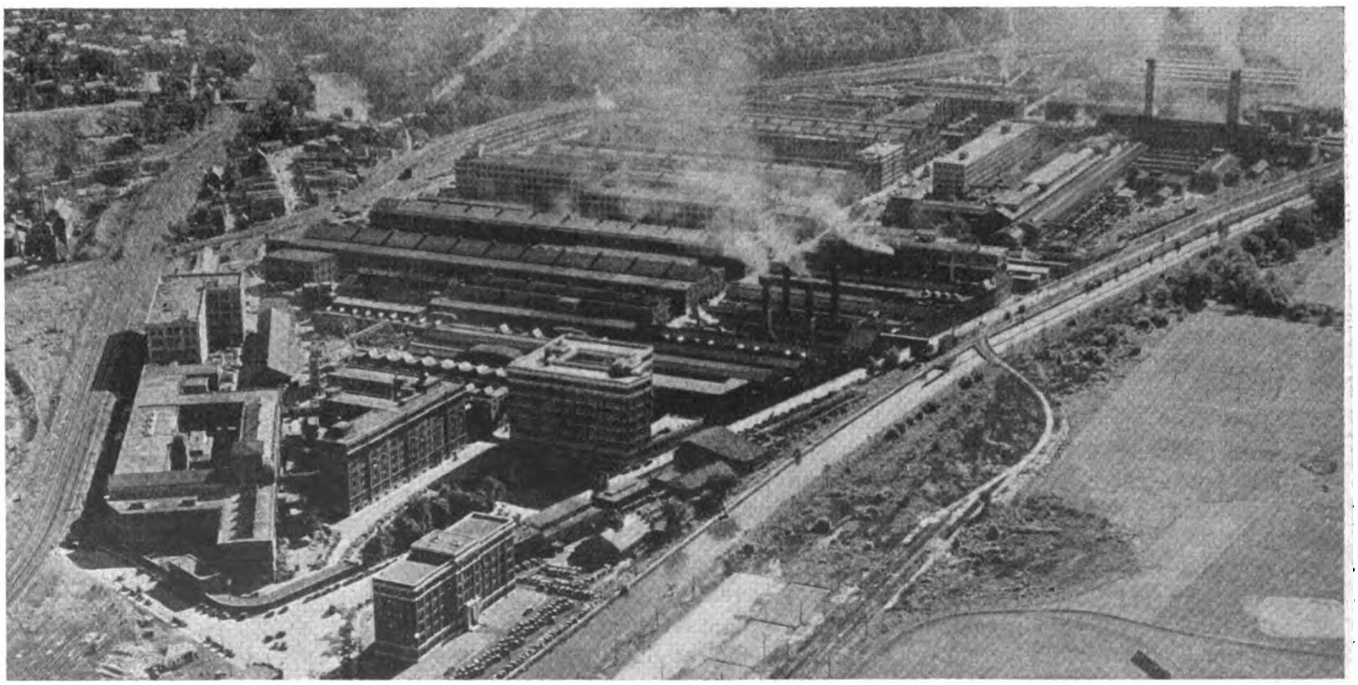
General Electric Company Allis-Chalmers Manufacturing Company
Westinghouse Electric and Manufacturing Company

These companies have been not only pioneers but continue to be leaders in the growth and development of equipment and methods for the generation and utilization of electricity in its multitude of commercial and industrial applications.

ELECTRICITY and its application have perhaps more than any other one thing been responsible for advancements made both commercially, industrially and scientifically in the past 50 years. Also, electric lighting is one of the few commodities which has shown a gradual reduction in cost from the beginning. Through improved methods of generation, transmission and utilization, the cost of a given amount of light is today only 5 per cent of its cost in 1880. It is largely through this reduction in cost that electric service is so extensively used in providing conveniences for the home, which have become necessities, and in the application of power and light in all lines of industry. The field, however, still has much room for development when it is considered that in the United States only 65 per cent of the manufacturing establishments and mines are electrically operated and only 38 per cent of the people live in electrically lighted homes. Additional applications of electricity to both home and factory are continually being developed. The extensive use of the radio is one of the most recent developments.

The broad application of electricity really dates from Sept. 4, 1882, when the first central station (the famous Pearl Street Station in New York City) was opened. Previous to this, electricity was in its experimental stages and at that time the telegraph was the only practical and established application. Electroplating was being done, however, and the telephone was in its infancy. Dynamos and electric lamps of various kinds had been invented but were not used commercially. This first commercial application, however, was quickly followed by numerous developments in many of the other types of equipment, such as motors, meters and numerous other kinds of equipment which are now common, everyday instruments. Many of these developments and inventions, which have brought electrical application up to its present high standing, have been recorded in the frontispiece pages of INDUSTRIAL ENGINEER during 1922.

In this development, the growth in the business of the General Electric Company, Schenectady, N. Y., Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., and Allis-Chalmers Company, Milwaukee, Wis., has closely followed expansion



An airplane view of the main office and works of the General Electric Company at Schenectady, N. Y.

The research laboratories of the General Electric Company are located here and all development work on new equipment is carried on at this plant until the designs are ready to go into quantity production when they are sent to some other plant of the General Electric Company. However, large turbine sets, large motors and generators, wire and cable and much of the equipment which is of a special nature is manufactured here. This plant covers a ground area of 523 acres and has a building floor space of over 6,000,000 sq. ft.; it employs approximately 25,000 workers. A multitude of industrial processes are carried on in this plant, as practically every kind of material is used in some manufactured product.

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Three of the several plants of the General Electric Company.

Equipment which is produced on a quantity basis is manufactured in these or some of the other plants scattered over the country. At Erie, Pa., Works (above) electric locomotives, railway motors, reciprocating air compressors, crane motors, turbine sets and other large equipment is manufactured. The Pittsfield, Mass., Works (upper right) manufactures transformers, lightning arresters, electric fans, induction motors, industrial heating devices and other equipment. The Lynn, Mass., Works (right) produces meters and instruments, transformers, small turbine sets (up to 7,500 kw.), textolite and fabroil gears and a variety of other equipment. These three plants occupy over 800 acres, have 8,000,000 sq. ft. of floor space, and give work to about 22,000 employees. The various Lamp Works occupy about 6,000,000 sq. ft. of floor space and have around 12,000 employees. The total manufacturing area of all the plants is around 25,000,000 sq. ft. of floor space.

in the production of electricity and its utilization.

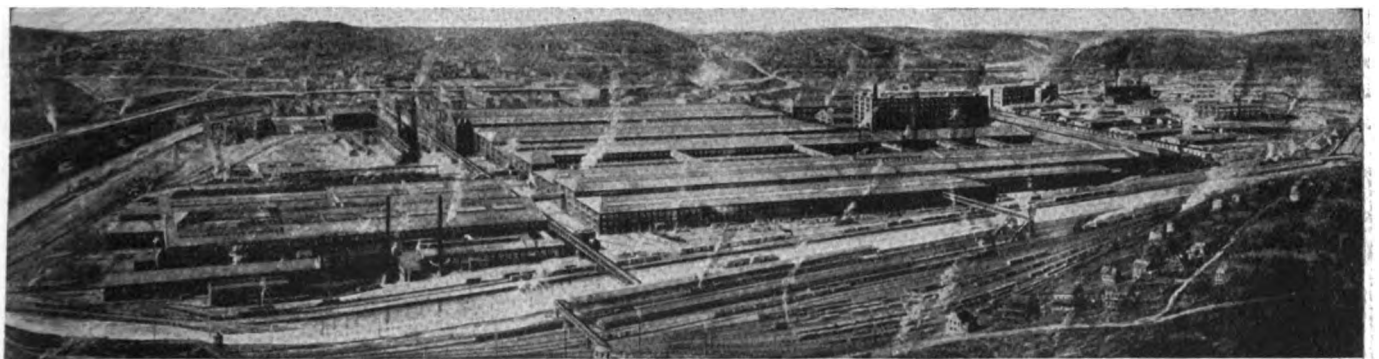
The General Electric Company was incorporated in 1892 and formed by uniting the Edison General Electric Company, the Thomson-Houston Electric Company and the Thomson-Houston International Electric Company. Because of the divergent ideas and methods employed by a number of individuals and organizations scattered all over the country, no great stride had been made up to that time in unifying electrical standards of generation, transmission and utilization which were so necessary to make the growth of the industry and its application universal.

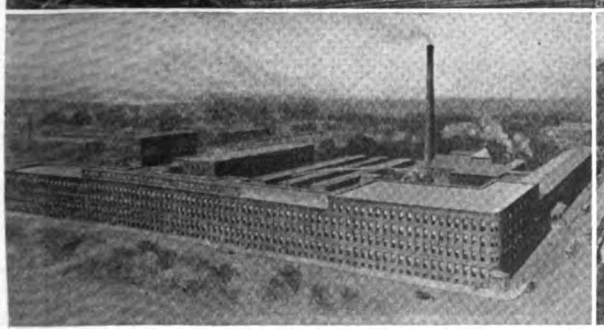
From a comparatively small beginning, this organization has grown until it is today the largest concern in the world devoted to the manufacture of electrical equipment. It has important manufacturing plants located at Schenectady, N. Y., Lynn and Pittsfield, Mass., Harrison, Bloomfield and Newark, N. J., Erie and Philadelphia, Pa., Fort Wayne, Ind., Cleveland, Ohio, Bridgeport, Conn., and lesser plants at many other points. The total land area of these plants is 2,050 acres; the total floor space of the buildings covers approximately 25,337,000 sq. ft. Over 75,000 persons are in the employ of the company.

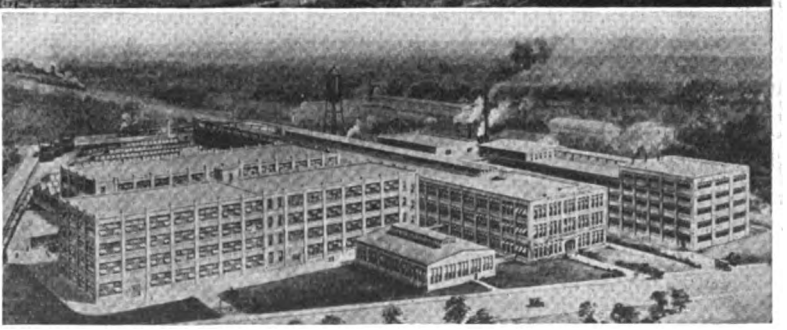
Such extensive work, ranging

Three of the plants of the Westinghouse Electric and Manufacturing Company.

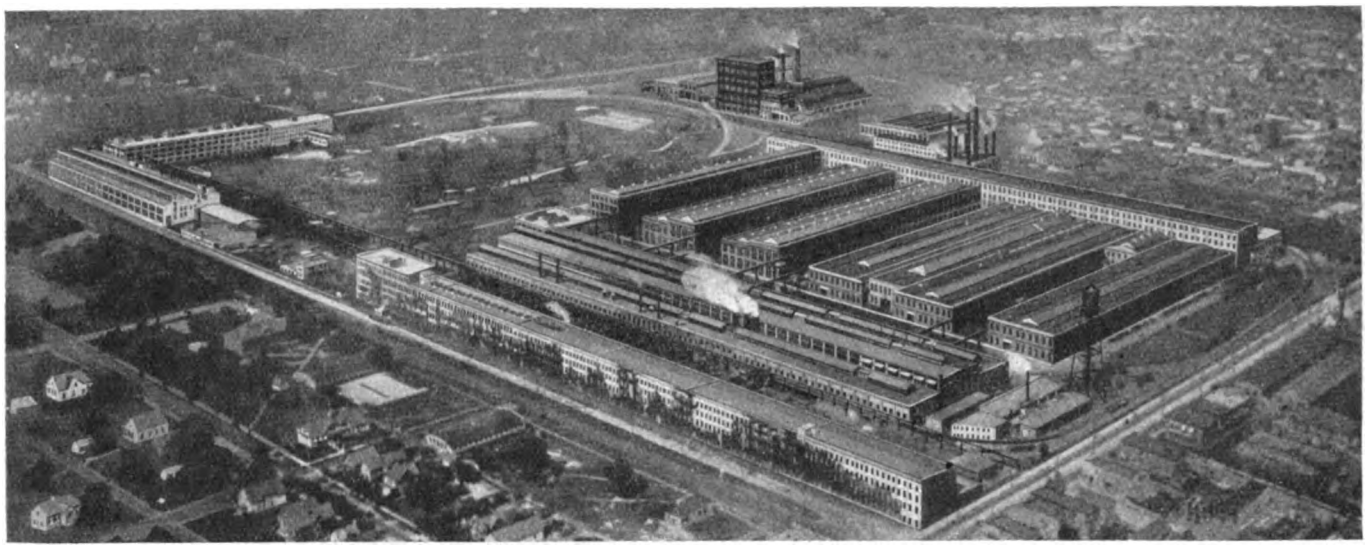
The main office and largest of the plants is located at East Pittsburgh, Pa., and contains more than 100 acres of manufacturing and floor space. In this plant the longest shop aisle is 70 ft. wide by 1,610 ft. long. Some 26 boilers with a total capacity of 28,000 hp. supply steam for heating the works and for driving Westinghouse turbo-generators which supply light and power. At the Bridgeport, Conn., Works (lower left) of the Bryant Electric Company over 500,000 sq. ft. of floor space are devoted to the manufacture of switches and electric wiring devices. The Bloomfield, N. J., (lower right) Works is one of the plants of the Westinghouse Lamp Company.







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The main plant and general offices of the Allis-Chalmers Manufacturing Company.

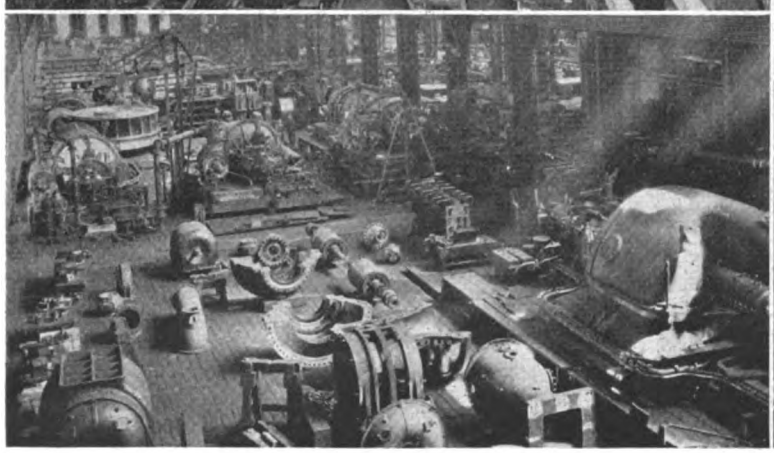
This factory is located at West Allis, a suburb of Milwaukee, Wis. Here the company manufactures a wide line of special heavy machinery for mining and metallurgical work and for cement, flour and saw mills, besides pumps, steam turbines, gas, oil, and steam engines, hydraulic turbines and a wide line of generating equipment, as well as motors for driving this machinery. In addition another factory, the Bullock Works at East Norwood, Ohio, a suburb of Cincinnati, is devoted to the manufacture of lines of smaller motors and other electrical machinery.

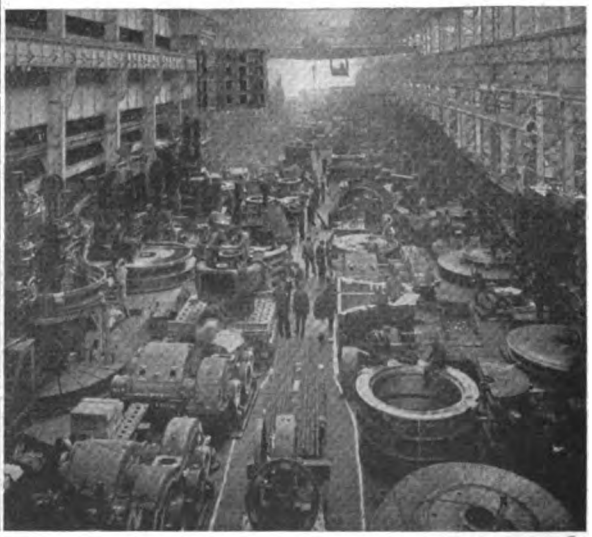
from the largest generating unit to the small pieces of apparatus, utilizes practically every known art, science and production method, including glass making, rubber working, casting, machining and forming of a large variety of metals, in fact practically all materials and kinds of refining processes are involved. Some of the work done in these plants is shown in the illustrations accompanying this article. In all, more than 500 different types of apparatus are produced, comprising electrical equipment for practically every class of industrial power application, lighting, mining, railways, central station systems and many others. The requisite standards of production and quality are maintained by adequate tests and a large research testing and standardizing laboratory.

About forty years ago, May 20, 1884, George Westinghouse began the manufacture of a new self-regulating dynamo for lighting service which had been invented by William Stanley, a young engineer. Up to that time Mr. Westinghouse had been manufacturing his invention, the air-brake, which is still used in train service, high-speed engines to

Departments devoted to the erection of heavy equipment at plants of the three companies mentioned below.

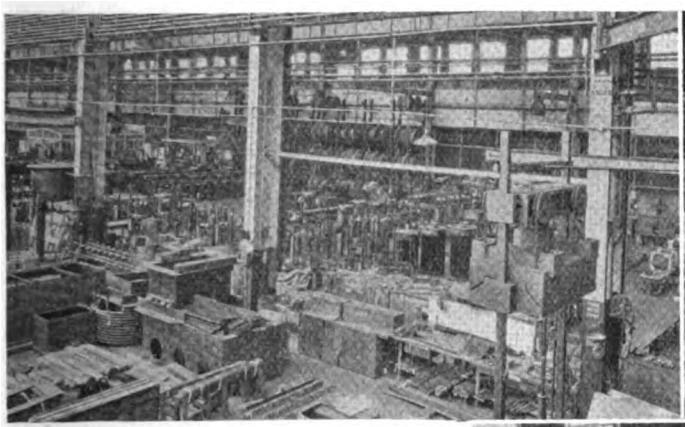


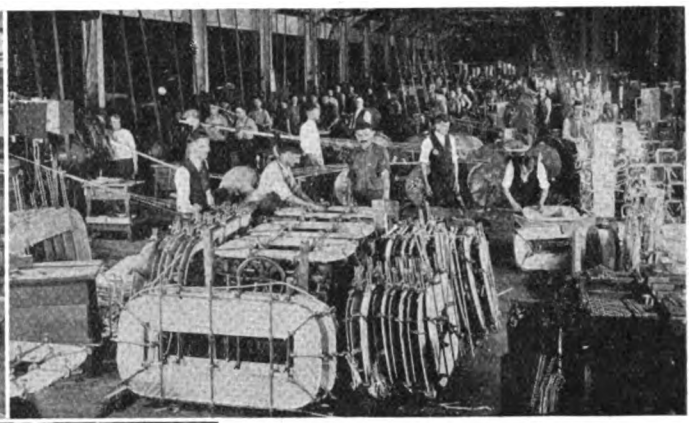




The illustration at the left shows a part of a manufacturing floor of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pa. After testing, the machines are placed on cars for the shipment to the consumer. The erecting floor of the Allis-Chalmers plant (lower left) shows one 10,000-kw., two 12,500-kw. and one 20,000-kw. turbo-generator sets in process of erection and test. The illustration at the right shows one bay of building No. 60 of the General Electric Company at Schenectady, N. Y., where steam turbo-generators ranging from 2,500 to 50,000 kw. in capacity are assembled and tested.

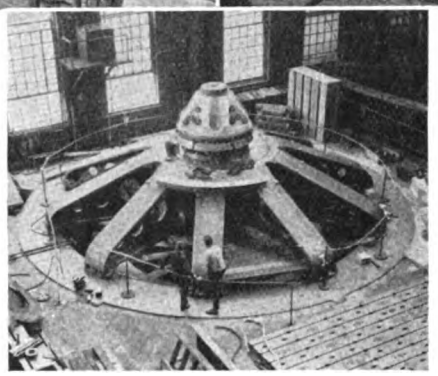
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Some of the manufacturing operations performed by the three companies.

The illustration above shows the transformer assembly department at the Pittsfield, Mass., Works of the General Electric Company. Some of the operations incidental to the winding of the coils for transformers at the East Pittsburgh plant of the Westinghouse Company are shown in the upper right illustration. The illustration at the right shows a complete assembly of the rotor and main bearing for one Niagara Falls, 65,000-kva., 107-r.p.m. waterwheel generator in a bomb-proof pit for overspeed test at the Allis-Chalmers plant.

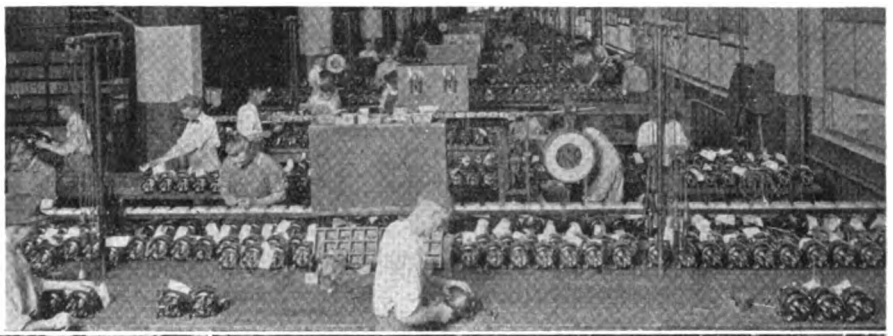


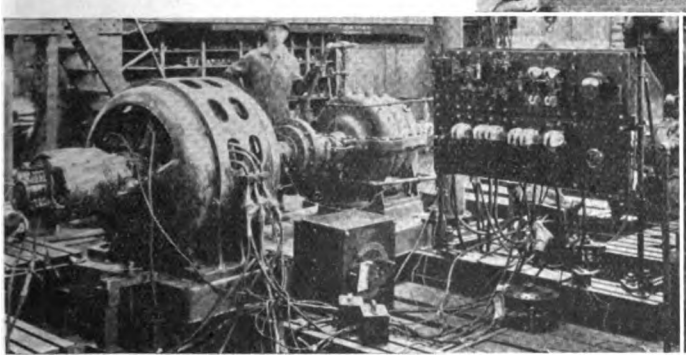
drive dynamos for arc lighting, and also controlled the Union Switch and Signal Company. At that time there was a big difference of opinion on the merits of direct and alternating current. Mr. Westinghouse favored alternating current and led in the development of a transformer to "reduce the pressure," a meter to measure the alternating current used, and a motor which could be used to do useful work. Perhaps the two outstanding early commercial installations were: the lighting of the World's Columbian Exposition in 1893 and machinery for the first hydro-electric development at Niagara Falls in 1895. The company has been a pioneer in many of the electrical developments made since. From a small factory in 1886 with 200 men on the payroll, the demands of the Westinghouse Electric and Manufacturing Company have increased until now it occupies 23 plants, many of which are devoted to the production of one class of electrical product, such as motors, lamps, fittings or other equipment. Approximately 50,000 men are now employed.

Development and research work is carried on at the main plant at East Pittsburgh, Pa. Other plants are located at Bridgeport, Conn., Cleveland, Ohio, Newark, N. J., Bloomfield, N. J., and other centers. In addition to electrical products, the company through its associated companies, manufactures air-brakes, stokers, water, gas and air meters, industrial and railway gearing, flexible (*Continued on page 46*)

Three other examples of the many operations required in the manufacture of electrical equipment.

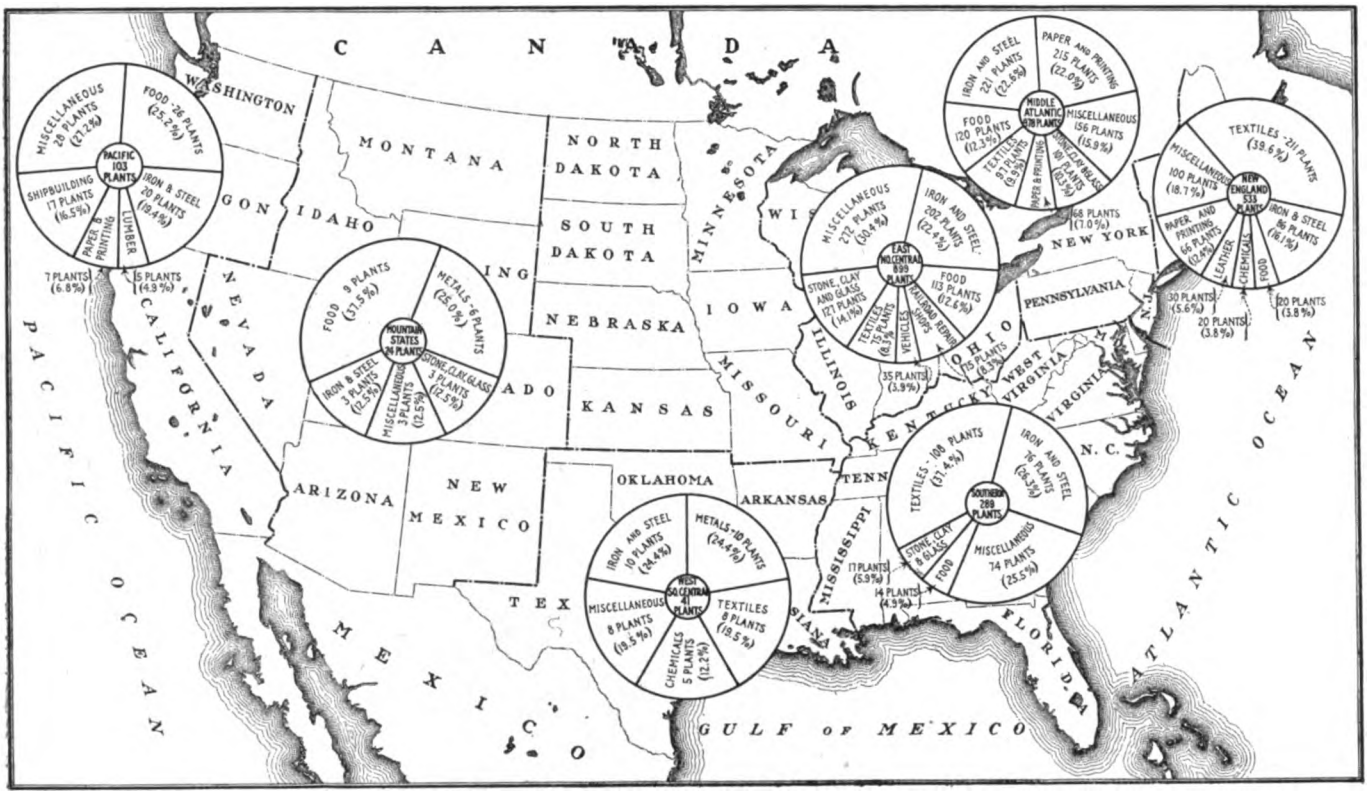
The illustration below shows a shop test of a 6-in., 4-stage Allis-Chalmers centrifugal pumping unit direct-connected through a magnetic clutch to a 225-kva. synchronous motor. The pump has a rating of 900 g. p. m. under a head of 310 ft. at 1,000 r. p. m. The illustration at the right shows the testing department for fractional-horsepower motors at the Fort Wayne, Ind., Works of the General Electric Company. A part of the large-motor winding department at the East Pittsburgh plant of the Westinghouse Electric and Manufacturing Company is shown in the lower right-hand illustration.







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This map shows the distribution of industrial plants in the United States using over 1,000,000 kw.-hr. of energy annually. This distribution of plants is based on an industrial survey conducted by the McGraw-Hill Co., Inc., and summarized on page 9.

Some of the Reasons for the

Growth of Well-Known Industrial Centers

Together with an Analysis of the Part Played by Available Sources of Power in Its Various Forms and Other Controlling Factors

By FRANK E. GOODING
Associate Editor, Industrial Engineer

THE main factors affecting the location of an industry include the source of raw material, market, labor supply and cost or availability of power. In the early days of American industry steam engines were expensive and not widely used. Therefore, available water power was one of the most important considerations and so a large number of the industrial centers in New England were built up around falls in small streams and rivers. This power had to be used where it was, since there was no means of transmitting it any distance. Incidentally, the measure of power used at that time was based on the number of spindles which the stream would operate satisfactorily.

The wider introduction of steam engines made the location of an industry more flexible, but to a certain extent this was dependent upon the supply of wood, and later upon coal, for fuel. Today, the facility with which electrical energy may be generated and transmitted hundreds of miles has enabled many industrial plants to take advantage of water power generated in the mountains (particularly in the West), where it would now be uneconomical to locate a plant. In other cases, water is used to generate power where it would be practically impossible to obtain coal for fuel. This is particularly true in some paper mill districts.

Today the expansion of certain well-established American industries and the development of facilities for the generation, transmission and application of power are going ahead hand-in-hand. Which is the cause and which the result may be a question for argument. A brief survey of the tendencies in the concentration of industry and the reasons therefor, is presented in what follows.

Industry in the United States may be considered as beginning in 1790, with the establishment of the first cotton mill, the Slater Mill at Pawtucket, R. I. Tanning of hides and production of lumber had been carried on before, but as more of a rough utilization of the natural resources of the country than as manufacturing industries. The invention of the cotton gin, which provided an adequate supply of cotton free from seed, gave considerable impetus to the cotton industry. Most of the market and labor supply, as well as available water power to drive the mills was located in New England. It was but natural that this industry developed in that part of the country.

With this early start, New England held the textile industry without much competition until about twenty years ago. Since then the

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Carolinas have rapidly forged to the front as producers of cotton goods. Some of the reasons for this have been the short distance from the Carolinas to the cotton supply, the availability of an adequate supply of labor and water power or cheap coal. There have been a number of other interesting shifts of industry from one location to another, some of which will be brought out later.

The first big impetus was given to expansion of industry by the early railroad construction. By 1848 railroads were running out of Chicago and by 1867 they had been extended on to the Pacific Coast. As the West opened up the railroads made new markets for industrial plants in the East. While a part of the market was moving west, raw materials, labor and power were still concentrated in the East. However, with the development of the moldboard plow, the reaper and self-binder, the United States, particularly that part west of the Alleghanies, became an agricultural country. Previous to this, the farmer could raise but little more than he needed for his family, because he could not take care of it, and so had but little left over to feed those engaged in industry. Agricultural machinery enabled him to raise, care for and harvest several times his own needs. Thus, with their food supply assured, industrial workers could concentrate in larger communities and devote their whole attention to industry. Soon after the Central West became populated, industries began to spring up here and there through the territory to supply the agricultural districts of the cities built up around them. It was necessary to use steam engines for power, as there were practically no water falls in the central section of the United States.

Value of Products Produced Annually in Fourteen Prominent Industrial Centers

CHICAGO DISTRICT—$5,000,000,000—Steel and steel products, slaughtering and meat packing, foundry and machine shops, printing and publishing, men's clothing, railroad cars and a very widely diversified line of miscellaneous industries.

DETROIT, MICH.—$2,000,000,000—Automobiles and automotive products and diversified manufacturing.

PITTSBURGH, PA.—$1,429,287,000—Steel, rails, pipe and tubing, tin plate, and steel products, pig iron, crucible steel, coke, glass, machine shop and foundry products.

JERSEY CITY, N. J.—$969,537,000—Meat packing, petroleum refining and diversified manufacturing.

NIAGARA FALLS, N. Y.—$900,000,000—Electro-chemical industries.

KANSAS CITY, MO.—$590,192,000—Flour and grist mills, meat slaughtering and packing, agricultural supplies.

BIRMINGHAM, ALA.—$550,000,000—Steel and iron, cast iron pipe, cement, brick and clay products.

CINCINNATI, OHIO—$500,000,000—Slaughtering and meat packing, foundry and machine shop products, men's clothing, boots and shoes.

MINNEAPOLIS, MINN.—$500,000,000—Flour milling and diversified manufacturing.

NEW ORLEANS, LA.—$315,000,000—Cotton and cottonseed products, sugar, and diversified manufacturing.

DALLAS, TEXAS—$145,000,000—Shoes and leather goods, cottonseed oil and byproducts, cotton ginning and milling machinery and diversified products.

ATLANTA, GA.—$130,000,000—Diversified lines of manufacturing particularly for cotton ginning and milling machinery.

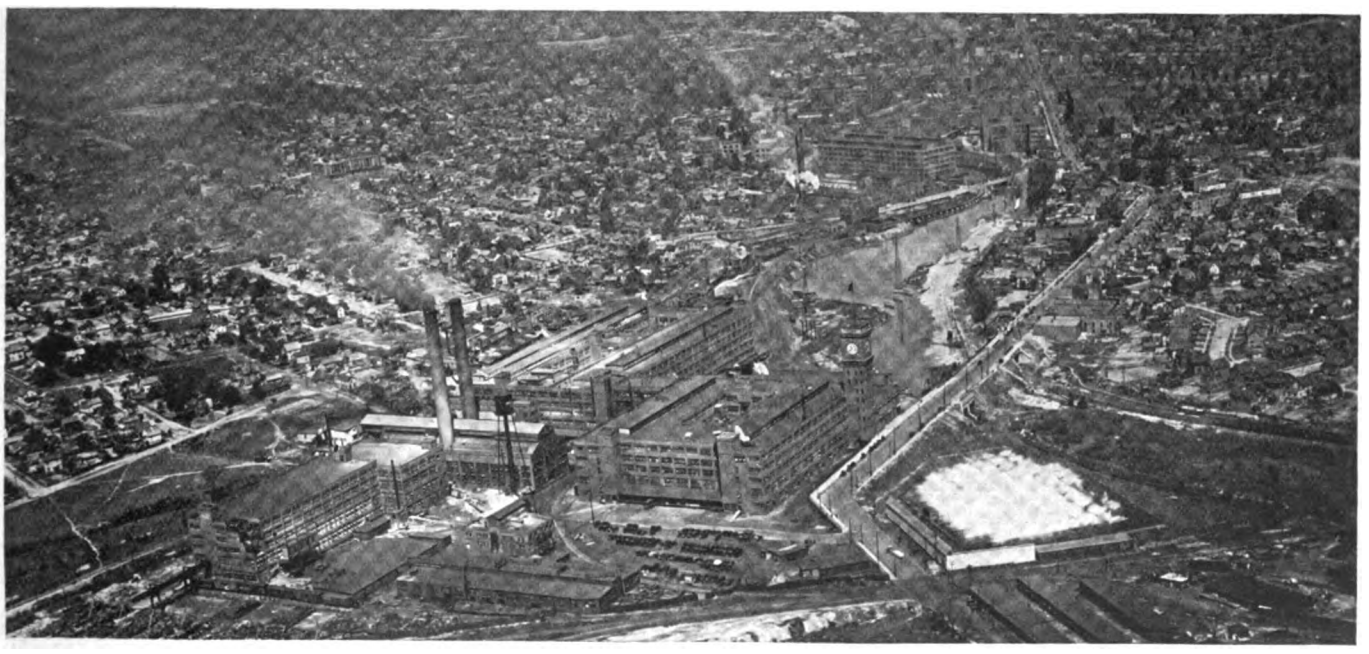
TACOMA, WASH.—$125,000,000—Lumber and furniture.

DES MOINES, IA.—$80,000,000—Meat packing, milling and diversified manufacturing, largely supplies to farmers.

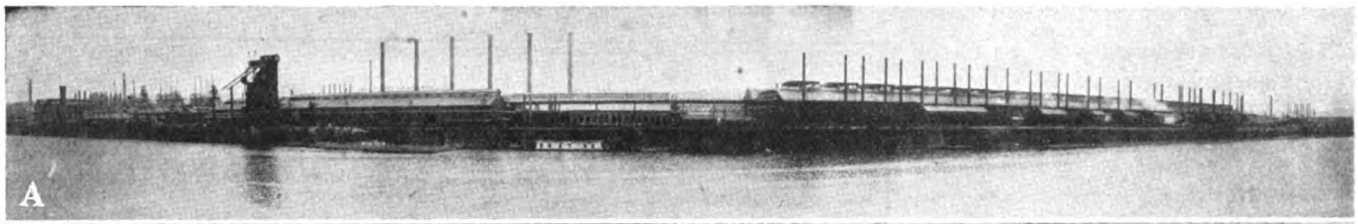
Agricultural implements were, of course, one of the big needs and thus many of the larger implement and wagon factories were built up in the Central West, such as the International Harvester Company, Studebaker Bros.' Wagon Works (now the Studebaker Corporation), John Deere Plow Company, Moline Plow Company, J. I. Case Threshing Machine Company and others. With the prestige obtained in implement work, many of these have added the manufacture of automobiles or

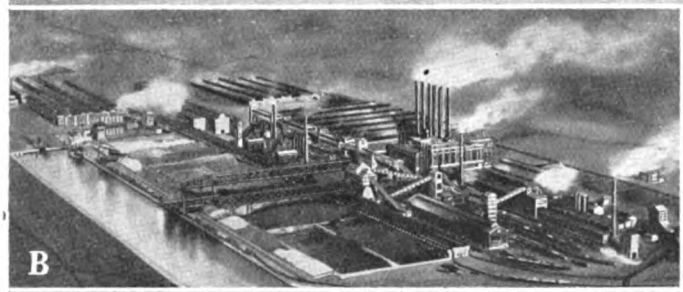
The name of Akron, Ohio, is always associated with rubber tires and other rubber goods.

This view shows the two main plants of The Goodyear Tire and Rubber Co. at Akron, Ohio. A branch was built at Los Angeles, Calif., a few years ago. The rubber industry is of comparatively recent growth and it almost parallels the development of the automobile industry. The Goodrich, Firestone, Miller and other large rubber plants are also located in Akron.



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Typical Plants Identified with Industrial Centers

A—Pittsburgh, Pa., has long been known as the "Steel City" and owes much of its growth to its favorable location at the junction of two rivers which give it a 40-mile water front and also to its closeness to the Pennsylvania coal fields and coke ovens. Illustration *A* shows the National Works of the National Tube Co., at Pittsburgh, Pa. Beginning at the left the different plants represent the steel works, blast furnaces, coal hoist, skelp mills, electric department, lap weld department, and butt weld department.

B and **C**—On June 4, 1924, Ford produced the ten-millionth car. These illustrations show the two main factories, *B*, the River Rouge Plant and, *C*, the Highland Park Plant. The Highland Park Plant occupies 278 acres of which 105 are under roof, and employs 65,000 workers. At River Rouge, with a plant area of 1,100 acres, the company operates the largest foundry in the world as well as a blast furnace, coke ovens, cement plant, machine shops, body plant, saw mill, paper mill, locomotive repair shop and a tractor plant, and has about 40,000 employees.

D and **E**—The first flour mill, at St. Anthony Falls on the Mississippi River, was established in 1822. Today the several flour mills grouped around these Falls at Minneapolis and St. Paul, Minn., are capable of producing 90,000 bbl. of flour daily. Illustration *D* shows the mills on the west bank, with the Washburn-Crosby plant in the foreground. Illustration *E* is of the Pillsbury plant, the largest mill in the world, and elevators on the east bank of the river.

F—Textile mills represent one of our largest industries and users of power. The cotton goods industry has a total of 1,863,542 primary horsepower and the silk, woolen and worsted industries have an additional total of 684,412 primary horsepower, all of which is about half electrified. This picture represents the cotton department of the Pacific Mills, a large textile organization with four plants at Lawrence, Mass. This one plant operates 184,096 spindles and 3,811 cotton looms.

G—Today, manufacture of machine tools is one of the important industries of Cincinnati, Ohio. Another important industrial development in this city is The Procter and Gamble Company Works, manufacturing soaps and many other products.

H—Lumber and lumber products are one of the important industries in the Northwest. About 40 of these plants are located in Spokane, Wash. One of the largest of these is the McGoldrick Manufacturing Co., which produces lumber and building supplies. Spokane is also surrounded by a large apple, grain and livestock center in addition to the timber areas.

I—Another important industrial plant of Detroit, Mich., is that of the Packard Motor Car Co. This plant, shown in the foreground, is one mile long. Several other large industrial works may be seen in the distance.

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trucks in the development of the industrial Middle West.

The invention of the Bessemer process of steel making and its introduction in the United States in about 1861 built up a big industrial center in the Pennsylvania coal region where the coal is made into coke and also used for power. The iron and steel industry was perhaps the first big user of power and created a demand for larger, more powerful and better engines. This industry has ever since taken an important part in the development of better power-generating equipment and heavy electrical drives for its utilization. In but few other industries is a continuous uninterrupted supply of power so essential.

More recently, two other steel-making centers have been built up, due partially to the finding of a better supply of ore closer to these centers and also their nearness to market. For example, the Chicago steel district at the southern end of Lake Michigan is close to the Central Western market. Also the iron ore can be hauled to it almost entirely by boat, which is the most economical method of transportation. Although it is somewhat farther than the Pennsylvania region from the coking-coal fields, it is cheaper to haul the coal the longer distance than the finished steel because coal, being a bulk product, has a very low freight rate, particularly when compared to finished steel shapes. The other iron-producing region is in the vicinity of Birmingham, Ala. This city has become an industrial center due to the closeness of iron ore and coal, as well as an adequate local supply of labor. Other large iron works and steel plants are scattered over the United States, but are located either in the vicinity of an iron or coal mining region or of a large industrial center.

Many other instances of the centralization of an industry are prominently identified with the expansion of certain industries in the United States. Part of this centralization was due to the feeling that where a number of industrial plants engaged in similar work were located in a neighborhood there would be a larger supply of semi-trained labor available, as men could shift from one plant to another, and take advantage of their former experience. While this is still of advantage, many concerns now prefer to build up in smaller towns and develop a more steady force of home-owners and workers, instead of depending upon a more or less shifting crew. Also the cost of land, and frequently buildings, is lower than in a larger city. Most large cities, however, have a fringe of industrial developments on the outskirts which take advantage of both large city and small community life. The city of Chicago is a typical example with its large industrial works at Gary, East Chicago, Hammond, Whiting, Chi-

Importance of Power in Some of the Larger Industries

Industry	Number of Establishments	Primary Horsepower		Cost of Fuel or Purchased Power	Value of Product
		Total Hp.	Electric Hp.		
Agricultural Implements	497	128,249	100,263	$ 5,038,512	$ 304,961,265
Automobiles, Parts and Bodies	2,579	542,224	490,560	25,320,519	3,304,726,138
Brick, Tile, Pottery and Clay Products	2,572	439,194	148,061	39,807,324	283,342,106
Car and R. R. Repair Shops	1,470	594,515	500,141	31,400,634	1,279,235,393
Cement	117	488,808	345,535	31,074,596	175,264,910
Chemicals	486	376,940	235,973	32,742,310	438,658,869
Cotton Goods	1,482	1,863,542	874,124	37,843,442	2,166,179,028
Electric Machinery, Apparatus, Supplies	1,345	438,839	479,366	13,739,110	997,968,119
Flour and Grist Mills	10,673	876,405	309,610	15,279,876	2,052,434,385
Foundry and Machine Shops	10,934	1,886,983	1,725,145	48,365,702	2,289,250,859
Furniture	2,867	275,935	143,691	6,595,339	597,405,141
Ice, Manufactured	2,778	572,970	158,552	25,606,264	137,004,798
Iron & Steel, Blast Furnaces	193	1,581,432	242,554	235,623,653	794,466,558
Iron and Steel, Steel Works and Rolling Mills	499	3,820,917	2,350,596	156,964,862	2,828,902,376
Lumber and Lumber Products	30,417	2,930,186	543,903	12,904,562	1,887,909,671
Paper and Wood Pulp	722	1,851,014	583,586	54,999,955	788,059,377
Printing and Publishing	24,636	362,123	331,500	12,251,441	1,536,408,283
Rubber Tires and Goods	404	354,188	304,367	12,605,943	987,088,045
Shipbuilding	934	553,711	476,135	15,604,092	1,622,361,361
Slaughtering and Meat Packing	1,004	371,925	223,769	24,089,789	4,246,290,614
Woolens and Worsteds	835	486,480	239,391	15,398,068	1,065,434,072
Smelting and Refining Copper	33	321,610	184,255	19,243,024	651,101,591
Total—All Industries	237,854	29,504,792	16,317,277	$1,645,986,556	$62,418,078,733

McGraw-Hill Compilation of Motors Installed in Industrial Plants in the United States

Industry	Motors Run by Purchased Energy		Motors Run by Energy Generated in Private Plants		Total Motors in All Plants		Distribution of Drives			
	Number	Total Rating, Hp.	Number	Total Rating, Hp.	Number	Total Rating, Hp.	Motors Under 5 Hp.	Belt, Number	Chain, Number	Directly Connected, Number
Agricultural implements	4,594	47,842	3,399	52,421	7,993	100,263	2,012	3,632	241	4,120
Chemicals and allied products (total)	73,019	1,235,704	60,827	962,164	133,846	2,197,868	40,500	78,576	8,120	47,150
Rubber and rubber products	9,711	194,018	7,355	162,608	17,066	356,626	.....	.....	.....	.....
Glass and glass products	8,378	69,714	6,395	90,713	14,773	160,427	.....	.....	.....	.....
Chemicals	27,597	377,523	20,306	267,315	47,903	644,838	.....	.....	.....	.....
Smelting and refining of metals	5,058	173,495	4,787	111,768	9,845	285,263	.....	.....	.....	.....
Artificial gas manufacture	1,413	33,363	1,822	22,040	3,235	55,403	.....	.....	.....	.....
Miscellaneous chemical industries	20,862	387,591	20,162	307,720	41,024	695,311	.....	.....	.....	.....
Electrical equipment and machinery	42,023	235,605	38,472	243,761	80,495	479,366	46,400	47,931	764	31,800
Food and kindred products	118,234	1,056,146	37,589	392,560	155,823	1,448,706	68,500	93,493	20,330	42,000
Iron and steel and their products	166,794	2,376,931	124,199	2,579,474	290,993	4,956,405	73,230	131,993	8,800	150,200
Leather and its products	23,057	144,635	11,505	120,355	34,562	264,990	13,880	31,298	1,754	1,510
Lumber and its products	45,878	462,777	23,079	323,186	68,957	785,963	25,400	50,449	2,678	15,830
Liquors and beverages	14,420	87,718	11,164	85,898	25,584	173,616	11,230	15,344	3,340	6,900
Metals and metal products other than iron or steel	56,991	543,574	21,016	223,485	78,007	767,059	40,490	55,680	3,887	18,440
Bituminous and anthracite coal mines	23,088	889,539	24,849	893,214	47,937	1,782,753	16,640	12,712	1,825	33,400
Metal mines	11,274	507,461	5,599	273,241	16,873	780,702	5,850	4,501	642	11,730
Stone quarries	3,971	156,810	490	19,210	4,461	176,020	1,548	1,228	170	3,063
Miscellaneous mines and quarries	932	30,636	771	46,635	1,703	77,271	591	454	65	1,184
Petroleum and natural gas	1,849	45,134	1,330	28,166	3,179	73,300	1,103	848	121	2,210
Paper and printing	160,151	623,706	27,768	413,835	187,919	1,037,541	95,600	150,879	8,040	29,000
Railroad-shop construction and repairs	19,187	325,313	25,558	404,349	44,745	729,662	5,615	13,020	1,790	29,935
Stone and clay and their products	21,440	563,263	7,947	225,365	29,387	788,628	9,420	16,817	3,720	8,850
Textiles	157,760	959,845	69,019	720,952	226,779	1,680,797	136,800	100,609	18,170	108,000
Tobacco	3,382	14,430	1,842	13,447	5,224	27,877	3,532	4,543	114	567
Vehicles for land transportation	61,408	475,853	14,199	125,976	75,607	601,829	36,520	45,977	4,150	25,480
Miscellaneous	27,662	194,214	9,456	82,599	37,118	276,813	20,750	20,328	2,460	14,330
Totals for all manufacturing industries, mines, quarries and wells of U. S.	1,037,114	10,977,136	520,078	8,230,293	1,557,192	19,207,429	655,611	880,312	91,181	585,699

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The city of Butte, Mont., which owes its growth to the copper mining and reduction developments surrounding it.

cago Heights, Harvey, Cicero, Joliet, Aurora, Elgin, Waukegan and North Chicago.

Although slaughtering and meat packing is the largest single industry in Chicago proper and iron and steel products the largest for the surrounding district a wide variety of miscellaneous industrial developments have centered here due to the central location. Chicago is a big railroad center with direct transportation to almost every part of the United States. The Lake transportation is also an important reason for the growth of this district. Boston, Philadelphia, Baltimore, New York City and many other large cities have a similar fringe of industrial towns surrounding them.

Today transportation to market and transportation of raw materials are two of the most important factors in deciding on plant location. For example: Minneapolis, Minn., was and still is the center of the flour milling industry. This was largely due to its location at practically the only available water power site in the Middle West and also to its closeness to the big wheat-producing sections. The works now at Niagara Falls and Keokuk (Iowa), on the Mississippi River are comparatively recent and due to water power developments at these points.

Labor required is not a big element in flour milling; power and supply of wheat are. The flour market is everywhere. Wheat is easier shipped than flour and as freight rates increased it was but natural to start flour milling centers elsewhere until now there are two other important centers, although they are not as large as the first. These are around Buffalo, N. Y., and around Kansas City, Mo., and in Kansas. The Kansas milling center has the advantage of being in the center of the wheat fields and also it has a big flour market around it. Power is no cheaper but transportation on both wheat and flour is lower. Buffalo, N. Y., is at the end of lake transportation which is much cheaper on bulk wheat than on flour and also is near the center of the Eastern flour market. Niagara Falls offers a low power cost.

A flour milling industry of considerable size has been developed on the Pacific Coast for similar reasons. Also many small flour mills are being erected over the country to take advantage of local supply and market. There seems to be a decentralization of this industry. Cost of freight or transportation is probably the principal reason for this decentralization in flour milling as well as in some other industries. It is much cheaper to ship the coal and raw materials considerable distances if freight transportation on the finished product can be materially reduced. Raw material and coal go at cheap bulk freight rates while most finished products have a higher shipping cost and are frequently easily damaged and more bulky, as for example shoes in cartons compared with leather. Comparatively recent and important shoe centers are being built up around St. Louis, Mo., Milwaukee, Wis., and Chicago, Ill., although Massachusetts and New York have been the centers of the shoe industry.

There are many other industries which have attached themselves to certain localities or cities so that a reference to the city almost instantly calls to mind the product. For example: Akron, Ohio, is associated with the rubber industry; Grand Rapids, Mich., with the furniture industry; Pittsburgh, Pa., with steel; Lowell, Mass., and Charlotte, N. C., with the cotton mill industry; Denver, Colo., Butte, Mont., and Salt Lake City, Utah, with mining; Hollywood, Calif., with motion pictures; Chicago, Ill., with meat packing; Rock Island and Moline, Ill., and Davenport, Ia., with agricultural implements; Battle Creek, Mich., with breakfast food, and so on. This does not mean that these are the only industries of these cities, but that those mentioned are among the more prominent.

Detroit, Mich., for example, is associated with automobiles, although it has numerous other large industrial plants. This year the total output of Detroit plants was valued at about $2,000,000,000 and a large proportion of this was automobiles and automobile parts. Detroit got an early start in this industry and many of the largest automotive concerns have established their main plants there. Many other automotive concerns are established in other Michigan cities such as Lansing, Flint and others.

The tendency today, however, seems to be toward building large assembly and semi-manufacturing branch plants in other sections of the country. Ford, for example, has built a large plant in the Chicago district and is building a plant to utilize the water power on the upper Mississippi River, above Minneapolis and St. Paul, Minn. Other sub-plants are built in other sections of the country. These take advantage of being nearer the market as the freight rate on an automobile from Detroit to Kansas City, Mo., or any other city, is much less when shipped to the assembly or branch plants as raw material or unassembled parts than if it were shipped as a finished automobile.

To reduce freight rates is today one of the most important reasons for establishment of plants in any location, as now power can be obtained almost anywhere at about the same cost. Also in many industries, particularly light manufacturing, power is a small item of expense.

Many other centers have been built

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up to take advantage of freight savings. For example, Los Angeles, Calif., is becoming an important branch factory or warehouse center for concerns distributing to the Pacific Coast and to foreign countries. The Goodyear Tire & Rubber Co. a few years ago built a large branch factory at Los Angeles. Kansas City, Mo., and Omaha, Neb., have, for the same reason, become centers for the territory between them and the Rocky Mountains. Similarly, Baltimore, Md., has had a rapid growth industrially as it has become a big exporting center, although New York City and its industrial community holds predominence. Baltimore gets many export shipments because it is closer to Chicago, Ill., and the Central West than is New York City.

Cheap power has been an important factor in the establishment of chemical and reduction plants in the Niagara Falls, N. Y., power district. In many of them the electric furnace is essential and is a big consumer of electric energy. Several similar industries have been built up in the Keokuk power district on the Mississippi River and in the West.

Because a city ranks high in any industry does not mean that it will always hold the field. Cincinnati, Ohio, for example, was once the leading meat-packing city. However, today over two-thirds of the livestock is raised west of the Mississippi River and a comparatively small amount in Ohio. Therefore, the big meat centers are Chicago, which lies between the hog, cattle, and sheep raising section and the market, and Omaha, Neb., and Kansas City, Mo., which are directly within the stock raising territory. Power is a small factor even though mechanical refrigeration takes an important part in the slaughtering and packing industry. Today Cincinnati is a leader in the machine tool industry, however, slaughtering and meat packing is still one of its largest industries.

The cement industry is one prominent example of an industry which is widely scattered over the country. The raw materials are found in many parts of the country and are quite heavy. The finished product is heavy, too, and its selling price is too low to permit much transportation expense. Therefore, cement plants are carefully located over the country where the cost of transportation for raw materials, coal and of the finished material to the market are carefully balanced. For this reason the plants are widely scattered over the country, usually near some large city so that they can supply the local building and paving demands. Several mills may be near large cities like New York and Chicago because the market is so large.

Coal for burning the cement and for power is a big item as it requires about 50 lb. of coal for each 100 lb. of cement. This makes the cement industry one of the largest users of power relative to the value of product handled. The blast furnace industry is the largest user of fuel and power as will be seen from the accompanying tables. The coking industry, which is practically all fuel, ranks second in total value and the steel works and rolling mills, third.

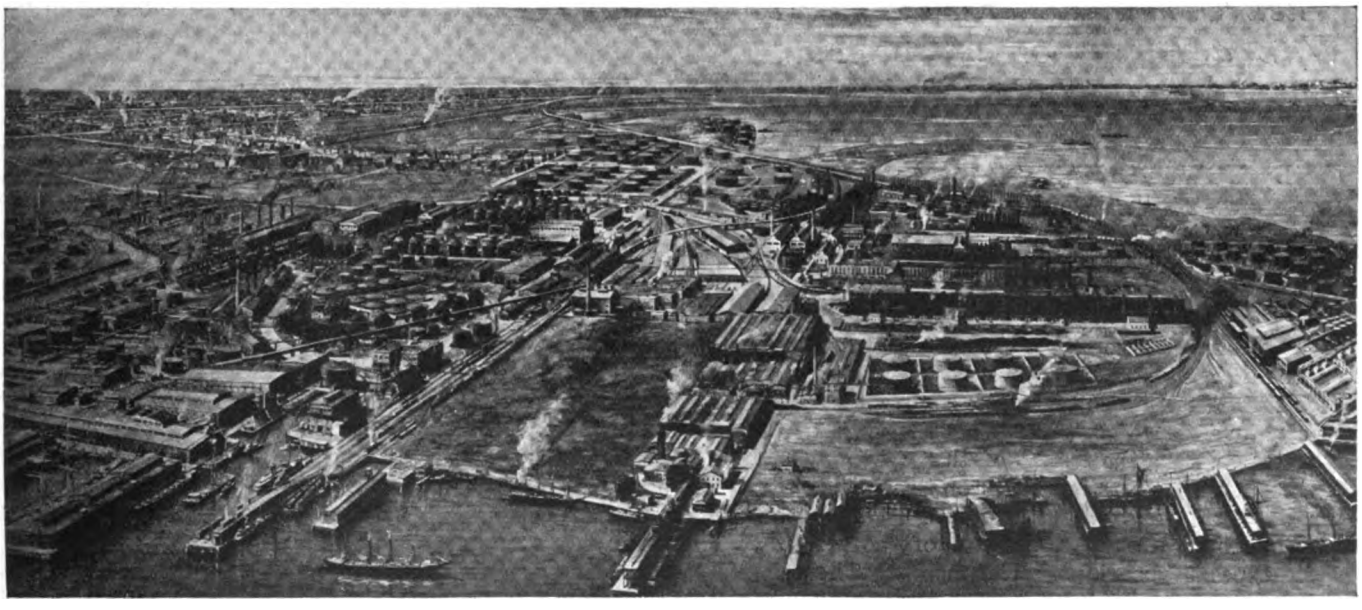
Some interesting figures may be obtained by carrying through some of the additional computations between the figures given in the table, page 9. For example, in cement mills the cost of fuel and power is 17.25 per cent of the value of the finished product. Also, each primary horsepower in plant capacity produced only $350 worth of product. In ice manufacturing, which uses practically all its fuel for power, 11.4 per cent of the value of the finished product is expended for fuel or power. Here each primary horsepower capacity produces only $240 in finished product annually. On the other hand each primary horsepower in the flour milling industry produces $2,344 worth of finished product.

The industry manufacturing brick, tile, pottery and other clay products also is a large user of power in that 14 per cent of the total value of the finished product goes into power and fuel. Each primary horsepower produces about $655 worth of finished product. At the time this census was taken only about 34 per cent of this industry was electrified, whereas about 70 per cent of the cement industry is electrified. However, in the period from 1914 to 1919 the amount of electrical horsepower used in the brick and other clay products industry increased from 86,779 hp. to 148,061 hp.

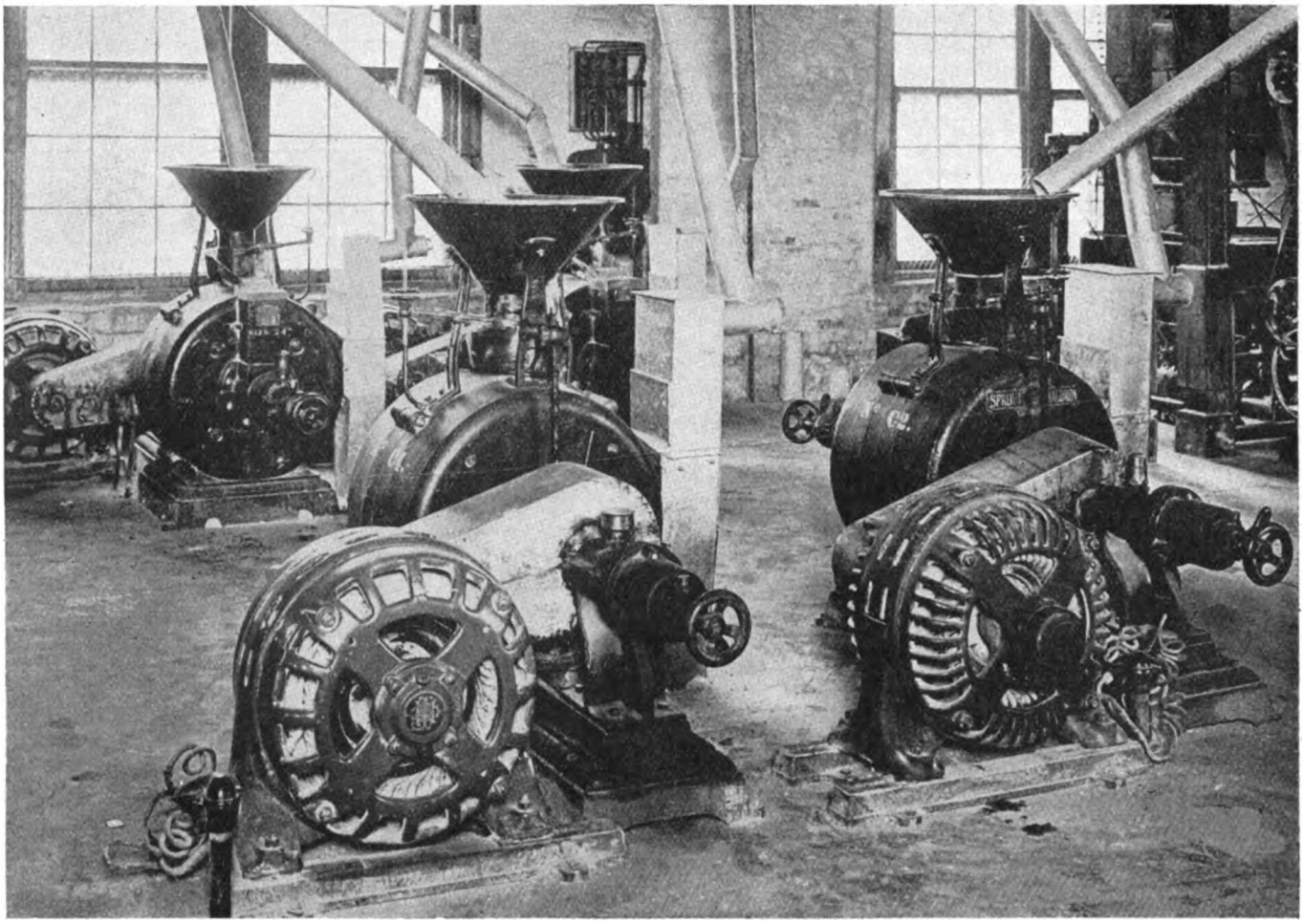
Six industries, as may be seen from the table on page 9, each show more than 1,500,000 horsepower. (*Continued on page 46*)

One of the largest petroleum refining plants.

This is the Bayonne, N. J., refinery of the Standard Oil Co. This is an industry which requires large amounts of fuel for heat rather than for power. Oil refineries are distributed over the country near the market as the crude oil is transported in bulk in ships or pipe lines while the refined oil must be more carefully handled.



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The motor on the left is equipped with ball bearings while the motor on the right has sleeve bearings. Which type of bearing will prove superior in the long run? Both motors were made by Fairbanks, Morse & Co.

Designers and Operators Comment on the Question—

Do Ball and Roller Bearings Justify Their Cost

When Used in General-Purpose Motors?; Together With a Discussion of the Points of Comparison Between Ball, Roller, and Sleeve Bearings

By HOWARD MAXWELL

Designing Engineer, Induction Motor Department, General Electric Company, Schenectady, N. Y.

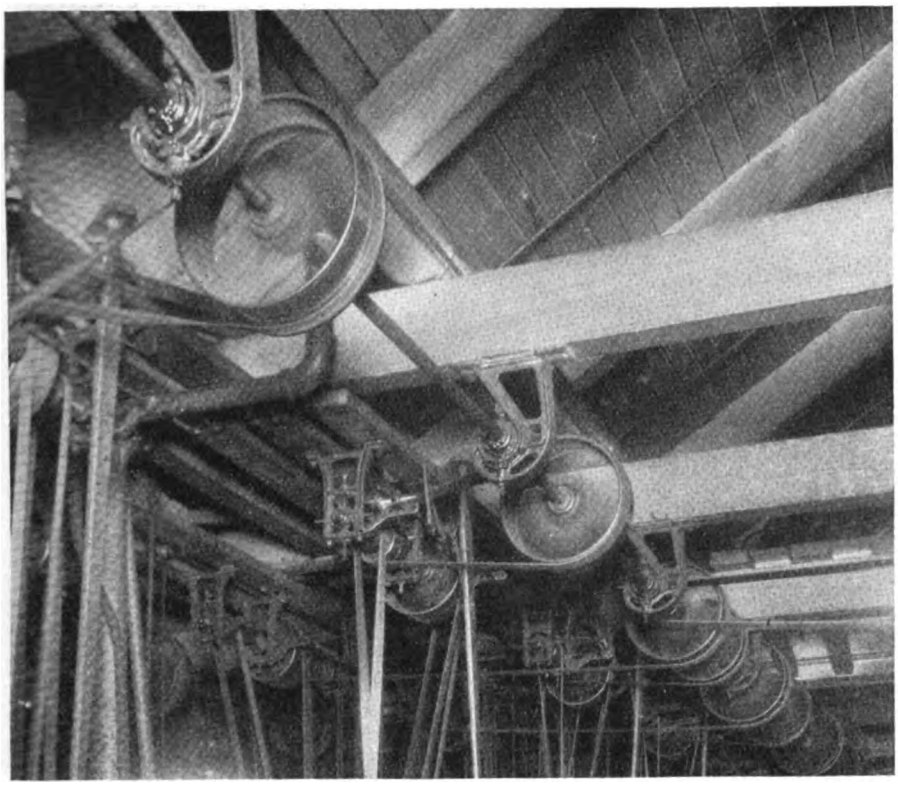
DURING the past 20 years or so, motor designers have endeavored to substitute ball or roller bearings for sleeve bearings for certain kinds of service and in certain types of machines. It is safe to say that the extent of their progress in this direction has been in direct proportion to the success attending their efforts in the use of these types of bearings. The most ardent proponents of ball and roller bearings have been impatient at times over what seemed to be the slow progress made in introducing these bearings into general motor use, but I think that even they would agree with me that if ball and roller bearings had been applied to all motors 15 or 20 years ago with the limited knowledge and experience available at that time, the results would have been very detrimental to the ball and roller bearing interests as well as to the motor industry.

There is today a growing demand for general-purpose, industrial motors equipped with ball or roller bearings, and many motor manufacturers who have not regularly supplied them heretofore are weighing the need of meeting this demand in their standard lines, so that it is well to consider at this time the progress that has been made in the use of ball and roller bearings.

The greatest assurance of success in the introduction of ball or roller bearings into standard lines of motors at this time lies in the fact that the designers of these bearings now agree on many details on which there was in the past a wide diversity of opinion. Among these details may be mentioned the following:

Lubrication.—It is now agreed that light grease is to be preferred for use on general-purpose motors operating below 2,000 r. p. m. It forms a better seal against the intrusion of grit, and as it is less likely than oil to escape from the housing, less frequent replacement of the

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Here is a long lineshaft equipped with Strom ball bearings.
It is said that reduced maintenance is obtained through the use of ball or roller bearing hangers on lineshafts.

lubricant, and consequently less attention, should be required. One of the principal advantages so far developed for ball or roller bearings over sleeve bearings as heretofore made, is in their so-claimed freedom from oil or grease leakage which finds its way onto the windings of the motor and causes insulation trouble. In order to make good on this claim where grease is used, it will be necessary to educate the motor users not to overfill the bearings, as there is no way to limit the quantity of grease inserted, as can be done with oil lubrication where overflow gauges are used to determine the oil level.

Standardization of Sizes.—During the past year the principal makers of ball bearings have all agreed to a list of sizes of bearings to be used with the different motor ratings. This list combining as it does the knowledge and experience of the many ball-bearing engineers into a single recommendation, is of the greatest assistance to motor designers and gives assurance to all that we are now better prepared to extend the use of ball and roller bearings than we have been heretofore.

This standardization of sizes is of the greatest importance to motor users in that it simplifies the problem of renewal bearings. Most of the ball bearings and some of the roller bearings are now interchangeable with each other, and if motor makers use the same size bearings, or at least the same series of bearings, it becomes very easy to provide for supply parts. For this act of standardization we are indebted to the suggestions and help given by the steel-mill electrical and mechanical engineers.

Assembly.—It is commonly accepted that the inner race should be assembled on the shaft under a very light pressure fit, such as would be secured where the shaft is about 0.0005 in. larger than the inside diameter of the inner race. This will prevent it from rolling on the shaft as it alternates from loaded to unloaded side. In addition it is generally recommended to further secure the inner race between a clamping nut and a shoulder on the shaft.

The success or failure of ball bearings is closely allied to the manufacturing tolerances and assembly fits, as you probably all well know. If a 1-in. cube of steel be compressed so that its length is shortened 0.0001 in. it is being loaded 2,800 lbs. With this fact in mind you can picture the effect of any slight inaccuracies which tend to cramp the balls, and see that such unnatural loads may very easily exceed the normal capacity of the balls. I am quite confident that ball and roller bearing makers understand and are able to meet the tolerances required, and it is an evidence of their appreciation of the practical side of this that they now make the ball or roller clearance between raceways a little more free so that we can press the inner race onto a shaft where it is a little bit over normal allowance without cramping the balls.

Enclosures.—In the details of the enclosing covers at the ends of the bearing housing there may yet be some slight difference in methods of grooving recommended, but even here they all follow along the same general lines.

Ball- or roller-bearing-equipped motors now designed according to the above standardized practice and using the recommended sizes of bearings which are *one to three sizes larger than those commonly used before* should, it would seem, give satisfactory service. So it is no longer a question as to whether ball and roller bearings will or will not work satisfactorily in motors, but rather the question is whether or not the ball and roller bearings offer advantages over sleeve bearings which warrant their general use in the face of greater initial cost of the motor. I will confess that I do not know a simple answer to this question, and in fact I think it will require much more extensive use of ball or roller bearings in general-purpose motors than now exists in order to establish

MANY USERS of bearings are now asking the question which is embodied in the title of this article. In this article Mr. Maxwell states the factors that should be considered when deciding the question for a given bearing application. This discussion was presented at a joint meeting of the Chicago Section of the American Society of Mechanical Engineers and the Western Society of Engineers held in Chicago. L. A. Hillman, Research Engineer of the Strom Ball Bearing Company, presented at this meeting a paper which will be given in a succeeding issue of INDUSTRIAL ENGINEER. Arthur Williams, Chief Engineer of the Shafer Bearing Corporation, gave a third paper which has been abstracted and precedes the discussion of all three papers at the end of this article.

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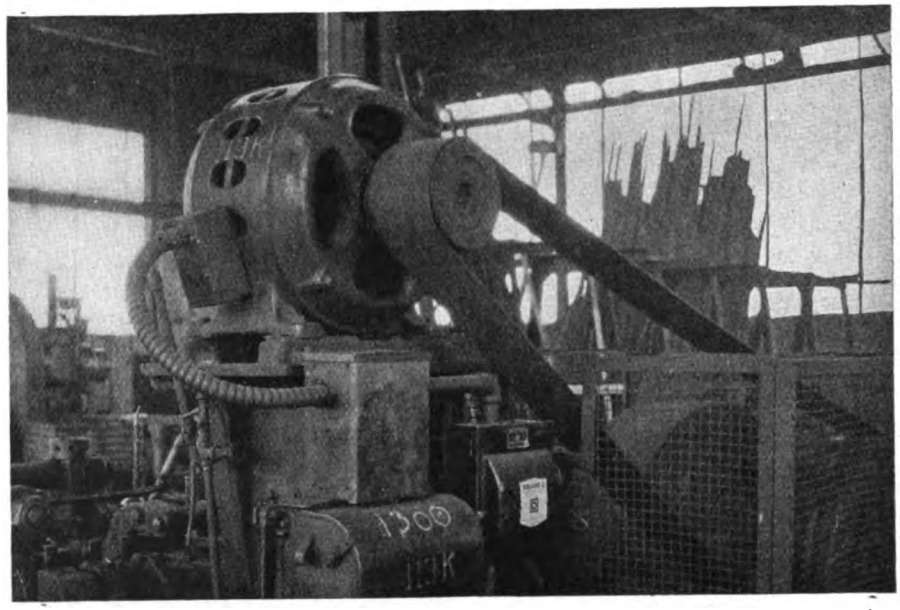
the comparative value of the various claims of superiority. However there are several points of comparison which are commonly made and can be intelligently discussed in the light of present experience.

Saving in Friction Loss.—I mention this first because it was one of the first claims made for ball and roller bearings. In fact, even today these bearings are commonly known and designated as anti-friction bearings. This idea originated perhaps because their static or starting friction is so low that it was quite natural to assume that they would have little or no friction under full speed. It was a great disappointment to motor designers to find out many years ago, when they first equipped their motors with ball and roller bearings, that these bearings had about the same friction loss as the oil-ring lubricated, sleeve bearing. We made very careful tests then, both at no-load and with the bearings carrying the load of a heavy flywheel. In making the load tests the motor with sleeve bearings and fly wheel assembled on the shaft was allowed to coast from full load to zero speed without power supply, and a deceleration curve plotted between time and speed. A similar deceleration curve was also taken with the same motor and fly wheel, but using roller bearings.

It was found after repeated check tests that a reduction in speed from 1,800 r.p.m down to 600 r.p.m. required 20 min. with either type of bearing, but from 600 r.p.m to zero speed the sleeve bearing stopped in 26 min. and the roller-bearing motor stopped in 38 min.

Many later tests made at no-load on both ball-and roller-bearing motors indicate that there is no appreciable difference in the friction loss of either type in motors operating at moderate or high speeds. We have taken the trouble to check motors of other than our own make equipped with both ball and sleeve bearings and find that they likewise show no difference in running friction loss.

Over-All Length of Motor.—When ball bearings were first used many years ago, it was quite common to recommend much smaller sizes, and also lighter series of bearings than is customary today; so the impression was then formed that they afforded a means of shortening up the over-all length of motor because being small in diameter they could be extended farther inside the motor.



Many motor users are putting ball or roller bearings on their motors in an attempt to reduce motor maintenance.
This motor, which drives a punch, is equipped with Strom ball bearings.

With the larger bearings now standardized and commonly used, the outside diameter of the bearing housing is too large to extend inside the rotor windings and so it has been our experience that the dimension of length over the bearing housings cannot be made less on the ball- and roller-bearing motors, at least in the smaller sizes, up to 50 hp.

Smaller Air Gaps.—It has been proposed to reduce the radial clearance or so-called air gap between the rotating and stationary members of a motor where ball or roller bearings are used, and therewith rearrange the design to reduce the cost or improve the motor characteristics and thereby profit by this reduction. The air gaps now commonly used in induction types of motors are now quite small and are generally thought to be the minimum required by considerations other than bearing wear or clearance. They vary from about 10 or 12 mils on a 1-hp. motor up to about 30 to 35 mils on a motor of 50-hp. capacity. I have yet to find a designer who had the courage to make the clearance much smaller with any kind of bearings. On direct-current and synchronous motors the air-gap clearances are much larger, but they are set by electrical requirements and would not be made smaller with other types of bearings.

Maintenance Costs.—When we take up the subject of maintenance costs we will find data presented and opinions expressed by those using motors in certain classes of service which show a very considerable advantage on the side of ball and roller bearings over sleeve bearings. This advantage appears in motors used in foundries, steel mills, cement mills and other locations where the air is laden with gritty dust. I believe that this kind of service offers the most promising field for the immediate extension in the use of ball- or roller-bearing, general-purpose motors.

It is not argued that ball and roller bearings suffer less from the effects of grit in the lubricant, but that the form of enclosure and the use of grease instead of oil prevent the entrance of grit into their housings. The designers of ball and roller bearings have thus indicated to the designers of sleeve bearings the need of more attention to dirt seals and in the past several years this detail has received more intelligent consideration so that the modern, sleeve-bearing motor is much improved over its predecessors in this respect. It is often contended that the present comparison of bearing life in dirty places is based on old designs of sleeve-bearing motors, but it seems to me that even so it still remains for sleeve-bearing designers to prove that their bearings are or can be made equal to ball and roller bearings in this respect.

Where the bearings fail and have to be replaced every few months, as has been occasionally reported, the maintenance cost runs into very large figures each year, and it then overshadows all other considerations. And in plants suffering acutely from such trouble I do not expect those responsible for maintenance to give much weight to other points favor-

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ing sleeve bearings. However, the number of motors located in such extreme conditions of grit-laden air are few as compared with the many in comparatively clean air, and thus the importance of this advantage becomes less when considered for a complete line of general-purpose motors.

Oil Leakage.—The escape of the lubricant from the bearing enclosure of sleeve-bearing motors is also largely a question of the design and manufacture of the housings.

A certain amount of this kind of trouble is due to careless filling of oil wells. The oiler frequently spills oil over the outside of the motor and many of them add oil too often when the motor is running. It seems possible that more trouble may arise due to too frequent oiling of motors than due to lack of attention causing the oil wells to run dry. So much has been said along this line recently that I have been watching a 15-hp. motor which runs continuously and which has now been operating nine months without addition to or change of oil, and judging from the amount of oil that has evaporated or escaped in any way so far, I expect that the motor will run another year without adding oil. This motor is not special in any way; it is equipped with the present standard design of sleeve bearing.

I think too much insulation trouble has been charged to the effect of oil on windings. While oil does tend to soften some kinds of insulating varnish and may in certain bad cases be the prime cause of insulation failures, still I do not think it is nearly so serious as a great many people have been led to believe.

Whether or not ball and roller bearings have and can maintain a just claim to advantage over sleeve bearings in this respect hinges on whether the attendants over-fill them with grease. When grease is inserted through a plug or high-pressure grease fitting, there is no indication that the proper amount of grease has been applied until it appears at the openings around the shaft. It is our observation that ball bearings are also generally over-lubricated. Grease is surely as detrimental as oil to the insulation of all coils.

Life of Bearings.—It would require a great deal more data than I have available, and in fact than I believe is available anywhere, to compare intelligently the life of sleeve bearings with ball or roller bearings used in motors. We know of a few ball- and roller-bearing motors that were built 10 to 15 years ago and are still running satisfactorily. We also know of some of the first induction motors sent to one of the southern textile mills over 30 years ago which have run continuously during the daytime and much of the time at nights, at a constant overload of 25 per cent; a recent investigation showed that six motors out of the 14 were running yet on their original sleeve bearings.

All this is interesting, but it does not add much useful knowledge on the life of bearings. We need to know what percentage of bearings, ball, roller, or sleeve, fail the first year, what percentage the second year and so on, but such data is not available for very many motor applications.

I have mentioned the life of bearings in order to bring out a point which has often occurred to me when considering ball and roller bearings. The journal of a sleeve bearing runs on a film of oil which separates it from the bearing surface, and under ideal conditions there can be no wear or deterioration in the bearing or journal; under such conditions its life is, therefore, infinitely long. In a ball or roller bearing the parts are in metal contact and are subject to rapidly-repeated stresses which deform the surface and bring into operation the laws of fatigue of metals. These laws teach us that metals subjected to repeated stresses eventually break down after a given number of repetitions of the stress, depending upon the magnitude of the maximum stress; therefore ball and roller types of bearings do have a certain, definite, useful life.

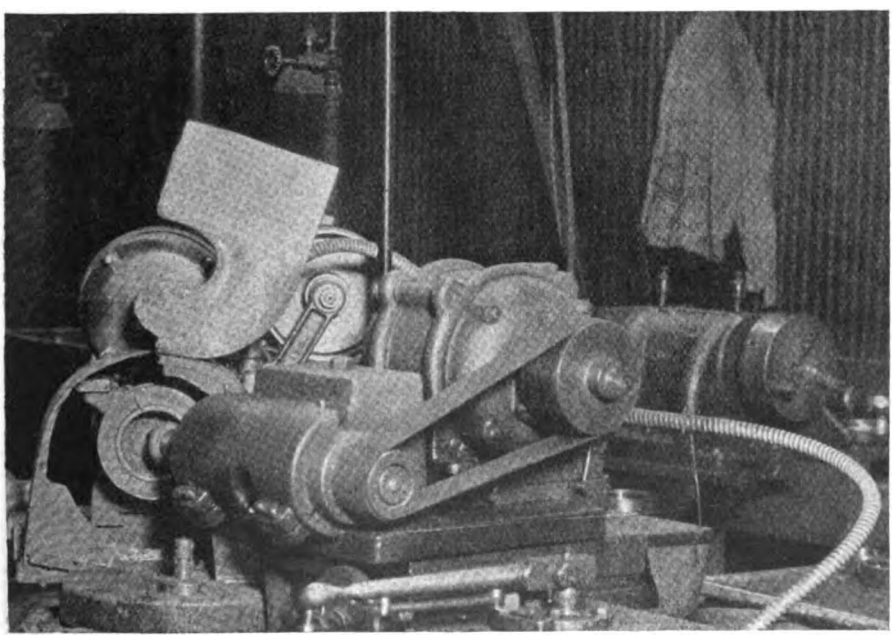
This is not an argument against the use of ball or roller bearings in itself, but it simply emphasizes the necessity of selecting ball or roller bearings large enough to avoid the overstressing of the parts.

I was very much pleased to find reference to this in a paper by Mr. Brunner printed in the May issue of the *Iron and Steel Engineer*, and to realize that the ball bearing engineers had investigated the life of bearings on the basis of fatigue. I believe we can, therefore, trust that their present-day recommendation as to sizes is on a very conservative basis of load rating.

Vibration and Noise.—Vibration is more readily carried through a shaft supported on ball bearings than through one cushioned on an oil film in a sleeve bearing. This is especially true for such periodicity of vibration as may be encountered with spur gearing and some of the worst cases we have encountered have been severe enough to crystallize the rotor windings. The noise made by the motor also is more noticeable with ball than with sleeve bearings. However, these points can generally be satisfactorily overcome if given proper consideration by the motor designer.

Cost.—The difference between a

This grinder motor would not start its load until the motor was equipped with ball bearings.
The motor is rated at 1½ hp., 3,600 r.p.m., and is equipped with Strom ball bearings.



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standard, horizontal, general-purpose motor equipped with ball or roller bearings, and one equipped with oil-ring lubricated, sleeve bearings, will vary somewhat with different companies, depending upon the development of their equipment and methods of making sleeve bearings and when expressed as a percentage it will, of course, vary considerably with the size and type of motors compared. I can however say with a fair degree of accuracy in approximation that on the squirrel-cage, or most popular type of motor now used today in sizes up to 50 hp., the cost will be increased at least 10 per cent by the substitution of ball or roller for sleeve bearings.

I realize that most of you are more interested in selling price than in manufacturing cost and that selling expediency may for a while establish prices on another basis, but I am sure that eventually the economic laws must bring selling prices in line with the cost of manufacture, in this case at least.

We cannot help admiring the ball and roller bearings made today as wonderful mechanisms excelling by far the precision attained in any other parts regularly produced for our machinery. It has required scientific and untiring attention to detail to develop the processes of heat treatment, manufacturing methods and machinery as well as careful inspection and testing devices.

These factors contribute to the high quality built into these bearings today and enable their makers to produce them at what seems to me so reasonable a cost. Perhaps their ingenuity will yet enable them to go further and produce the same high quality of bearings at even lower cost and, if so, this will greatly assist in promoting the use of them in industrial motors.

In the foregoing remarks I do not wish to convey the impression that there exists today any very great difference of opinion between ball or roller bearing manufacturers and motor manufacturers on the relative merits of the different kinds of motor bearings, because I feel that the many papers written, as well as the discussions and conferences held between them during the past year, have very effectively cleared up these divergent viewpoints.

Main Points in Discussion of Ball, Roller and Sleeve Bearings

Following Mr. Maxwell's paper, a paper on "Ball Bearings" was presented by L. A. Hillman, Research Engineer, Strom Ball Bearing Company, Chicago, Ill. Mr. Hillman's paper will be given in a succeeding issue of INDUSTRIAL ENGINEER.

A third paper was presented by Arthur Williams, Chief Engineer, Shafer Bearing Corporation, Chicago, Ill. His paper was on "Roller Bearing Application to Industrial Uses" and is abstracted in the following:

With the increased cost of labor and material, the engineer is called upon to design machinery requiring less skilled operators, less maintenance and which, at the same time, will have greater capacity and longer life. To attain these ends, he is turning more and more to anti-friction bearings.

Many of the failures of bearings have been due to faulty application. A large amount of this has been due to lack of knowledge on the part of the user of the necessary care in machining of component parts, improper fitting, lack of provision for sufficient lubrication, and of improper grease or oil for the lubrication.

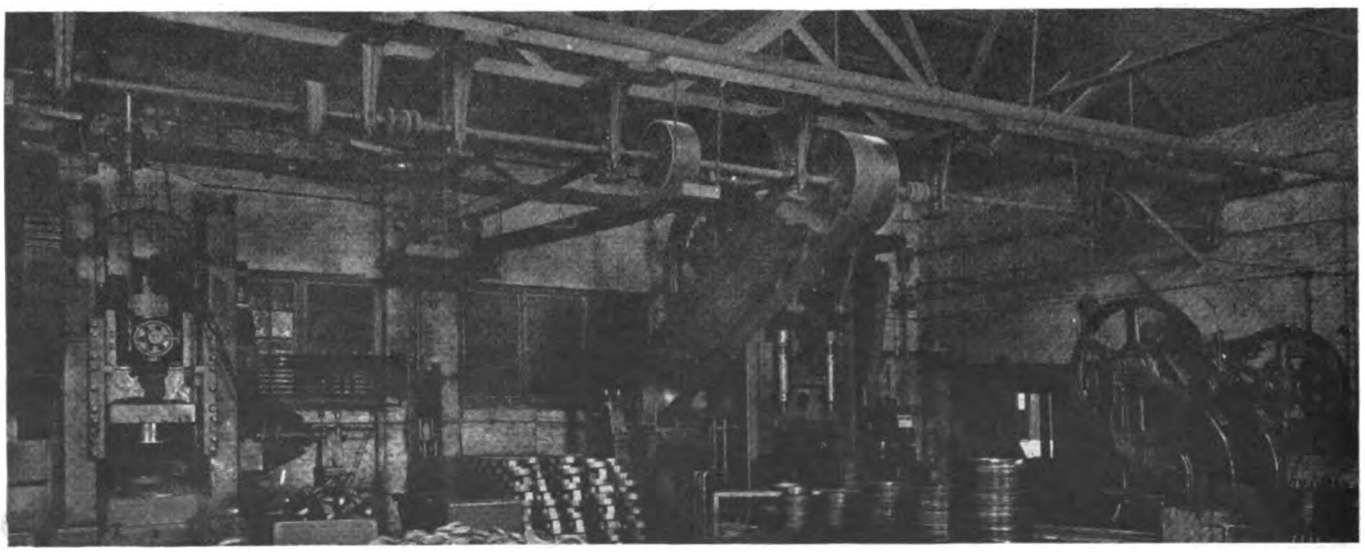
Fitting processes for different bearings vary greatly. For instance, a deep-groove ball bearing must not have a tight press fit on either the inner or outer race. The running clearance of the balls is so little that any expansion or contraction of the races will severely overload the bearing and cause an early failure. With ball or roller bearings of the adjustable type, the revolving member is generally a good press fit and the stationary member a creeping fit so as to allow for adjustment. Some roller bearing manufacturers recommend a press fit for all cups to counteract the bursting action caused by the thrust of the rollers.

Load capacity of the bearing cannot always be determined from a table because of so many unknown factors such as shocks, reversal of load, distortion, shaft whip, possible misalignment, and other causes that may come up. For this reason, most bearing engineers prefer to make recommendations on past practice. Where bearings are to be installed by millwrights or shop mechanics they are likely to be abused while being installed. For this reason, bearings going into such hands should be made as near foolproof as possible, even to the extent of making the entire assembly a detachable unit which need not be dismantled to be put on or taken off the shaft. Careful instructions should be issued on the mounting of bearings in order to make sure that they are pressed on or pulled off, for in many shops the sledge is often closer than the arbor press or the wheel puller.

Because the industrial field is so large and covers such diversified classes of machinery, it is impossible for one type of bearing to cover the field. The best bearing to apply at a given point is a matter to be determined by the engineer. In most cases any type of bearing can be used, the

Here is a lineshaft subjected to the strain and shock of large stamping machines.

The lineshaft is equipped with Fafnir double ball bearing hanger boxes.



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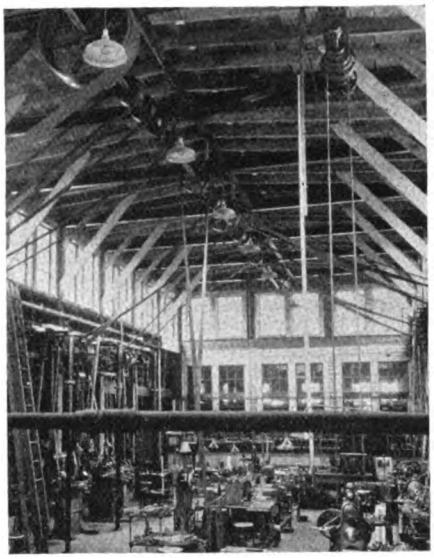
main question is, which bearing best suits the requirements of the application under consideration. Some of the determining factors that must be considered are:

Space.—Certain applications are largely determined by the space allowable for bearings. With little space between shaft and housing, and with unrestricted length, a non-adjustable type of bearing is required. Again where the overall length of the machine is important the narrowest bearing that will carry the load is required. In this case practically any type of roller bearing can be used. Often the bearing installation is such that the bearings, when once installed, are very difficult to get at. Here an adjustable bearing would be inadvisable. On the other hand assemblies are sometimes made much simpler and the construction of the entire machine can be simplified by the use of adjustable bearings. These factors must be gone over with the layout engineer.

Manufacturing Practices.—The type of machinery being built more or less determines the bearing best suited for the application, although no set rules can be given along this line. Generally, however, mill and elevator machinery makers cannot use to advantage as fine a type of bearing as can a machine-tool builder, whose product is noted for extremely fine workmanship and accuracy. Occasionally, however, rough machinery has been wonderfully improved by the use of high-grade, roller bearings.

Cost of the Bearing and Its Application.—The cost of the bearing is very small compared to the saving that it will make. For this reason, it is well to consider the bearing in the light of manufacturing requirements. One type of bearing may simplify the manufacture of the product or simplify the design or assembly of the machine. Here, again, different bearings can show advantages over others. On some applications, where alignment is hard to secure without greatly added expense, the bearing that will take care of slight misalignment has a decided advantage.

Efficiency and Maintenance.—It is not alone the saving of power that determines whether to use plain bearings or roller bearings. In many cases the saving in maintenance on large installations is a much greater factor than the saving of power. On the other hand, if the power saving is the primary factor, then the most efficient type of roller bearing should be used, depending on the service to which the bearing is to be put. The efficiencies of different types of roller bearings vary greatly, and no set of figures can be given which could be considered absolutely reliable. This is because certain factors come up that have decided influence on their efficiency. For example, misalignment of housings or severe deflections of shaft will cause a decided drop in efficiency of a solid roller bearing of either cylindrical or tapered-roller type because of pinching of the rollers. On the other hand, this same misalignment will cause practically no change in the efficiency of self-aligning bearings.



Reduced starting friction is an advantage of ball and roller bearings.
When the lineshaft shown here was equipped with sleeve bearings, the starting friction was such that it was necessary to pull the belt by hand to get the lineshaft under way. The lineshaft was then equipped with Fafnir double ball bearing boxes and the starting friction lowered so that it was unnecessary to install a larger or different type motor.

Lubricants used should be of just sufficient consistency to stay in the housings, for in any anti-friction bearing the principle function of the lubricant is to prevent drag of the retainer and to prevent corrosion of the bearings. The class of grinding finish on the bearings is also another factor which will change the efficiency somewhat. A roughly-finished bearing of the same type will show a lower efficiency than a highly-finished bearing.

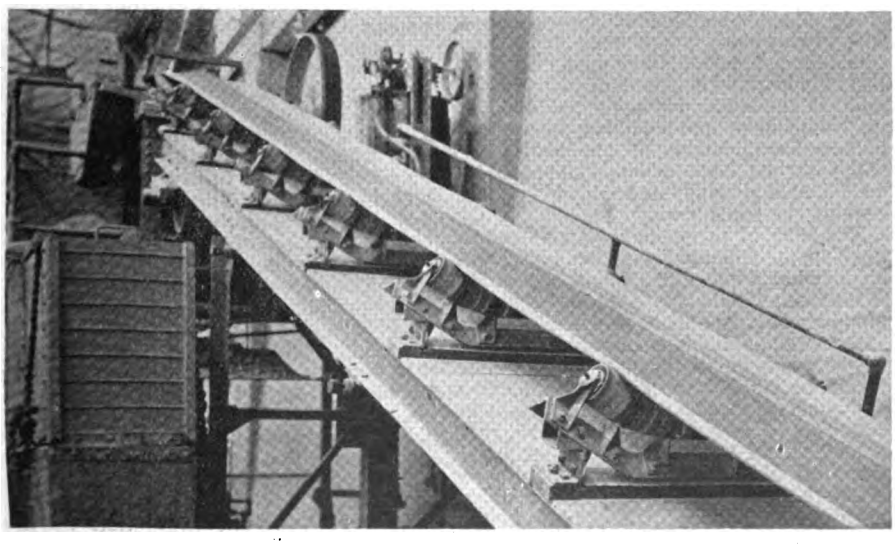
Installation.—The mountings of roller bearings vary with different types and should be in accordance with the recommendations of the manufacturers of the bearing to be used. A few general principles that should be followed are to make sure that there is ample provision for lubricant. If possible this lubricant should be so supplied that it will be able to circulate or distribute itself throughout the bearing and should the bearing run warm enough to melt, will not run out. Proper foresight along this line will insure the bearing running over long periods of time with little or no attention. Different kinds of grease retainers are being used, depending on the application. In some installations a felt ring is very satisfactory. This should be run on the shaft and should have just sufficient pressure to create an oil film and prevent the oil working out. Leather cup packings are being used successfully and where water or grinding compound is encountered the felt packing can be used with the addition of some type of labyrinth or slinger to positively throw the water away from the bearing while in operation and so designed as to prevent water from draining into the bearing when not running.

Following the presentation of Mr. Williams's paper, the remainder of the meeting was devoted to a general discussion of ball, roller and sleeve bearings.

In discussing the use of ball bearings in locations subjected to more or less dust and grit, Mr. Spencer of the Western Electric Company, recalled an interesting installation in the buffing and polishing department of that company. In this department, there are in use 50 double-end polishers equipped with ball-bearing, direct-current motors ranging in size from 2½ to 10 hp. The bearings used are of the self-aligning type and Mr. Spencer stated that so far as he knew they had had no trouble with them.

Mr. Spencer stated further: "I find that a great many machine designers are not particular enough about the location of oil grooves and the shape of them. Sharp-edged oil grooves defeat their purpose by scraping off the lubrication. On our drawings in the past, we have allowed or specified a running fit for bearings. In the future, however, we are intending to abandon this idea and will specify a definite clearance, as we consider that this is extremely important in a new bearing. I think that the initial clearance, the kind of lubricant, the method of lubricating the units, pressure, the speed of the journal, together with the alignment, are factors which are very important, in fact, as important as the materials of which the journal and bearings are made. They are very often neglected in machine design.

Ball and roller bearings find extensive application to the rollers of belt conveyors.
Reduced maintenance is said to be the principal advantage obtained in such an application. Strom ball bearings are used in this application.



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"We have at the Western Electric Company, probably hundreds of thousands of bearings. I think that approximately half are sleeve bearings and the other half ball bearings. The question arises constantly as to which bearing is the best for our purpose. With the highest speeds, as on some of our wire insulating machines, the ball bearings are used in the mounting of the spindles, while the main drive and intermediate shafts are usually mounted in bronze bearings."

Mr. Brown, of the Westinghouse Electric & Mfg. Company, pointed out that ball bearings, because of their extreme sensitiveness to abrasive material, such as dust, as found in cement plants, have from the first been very carefully enclosed, because of the fact that their life depended upon the enclosure. He said that these enclosures have resulted in retaining the lubricant, which is one of the great points in bearings and from the lack of which sleeve bearings have suffered.

On the other hand, in his opinion, sleeve bearings because they are not as susceptible to abrasive material and because a measure of success can be attained even with poorly designed enclosures, have been neglected to this extent and have given to the ball bearing its point of greatest argument for the position which the ball bearing strives to attain.

Mr. Brown felt that before sleeve bearings were given up for a given application, something further ought to be done in the way of securing a sleeve bearing which will accomplish the results desired. He thought that if the enclosures of sleeve bearings were designed in as systematic and painstaking a way as has been done with ball bearings, perhaps it will be found that the sleeve bearings can be retained and also the many advantages which are inherent in this type of bearing and which must be abandoned by the use of ball bearings.

Mr. Brown also spoke of the oil film which is found in sleeve bearings. He said: "This is one of the very important features of sleeve bearings, which must be abandoned in ball and roller bearings. The oil film is not, as we have heard, a delicate affair, but is an exceedingly strong film which can support great weight. The ordinary pressures in sleeve bearings are on the order of 50 lb. per sq. in. in moderate-speed bearings. The pressure which is necessary to force out the oil film and bring the metal of the bearing into contact with that of the journal is many times greater than this. The shock loads, therefore, provided for by the oil film are very great, and we should think twice before we abandon such an advantage as this.

"I am glad that the ball bearing and the roller bearing have come, because there are many applications where the sleeve bearing has heretofore been used where it is hardly suitable, and where we will find that the ball and roller bearing will be more suitable. Therefore, we should use it in order to obtain the best engineering design."

The fact that the starting friction for ball and roller bearings is low was commented on by several speakers. An example was quoted of motor-driven, mine fans in which the size of the motor had been considerably reduced, due to the fact that the heavy load could be started much easier on ball or roller bearings than on plain bearings.

Mr. Williams said that overloading motors from starting friction is a common occurrence. He spoke of trouble in getting under way a lineshaft which drove Cleveland automatics. The Cleveland automatic is a very heavy machine and uses a clutch instead of a loose pulley. The lineshaft was quite long and was driven by a 50-hp. motor. The entire lineshaft and countershafts had to be set in motion and, consequently, considerable starting torque would be required. Mr. Williams said that when large enough fuses were put on the motor to permit sufficient current for starting the lineshaft, the motor had absolutely no protection against overloading under ordinary conditions.

Another speaker discussed some interesting results of a test made on the street car system at Shanghai, China. These tests again show that in certain applications static friction is decidedly a factor in determining the amount of power consumed. In these tests a street car equipped with ordinary bearings was run through a route, at a certain speed and making the usual stops. This car was then equipped with ball bearings and run over the same route at the same speed and making the same stops. It was found that a saving of 25 per cent was obtained through the use of these bearings. Large ball bearings of Swiss manufacture were used.

In continuing the discussion, Mr. Maxwell said that the static friction referred to was the static friction of the load rather than the static friction of the motors. He said: "The friction of a motor with plain bearings is rather insignificant at starting. It amounts to approximately 15 per cent of the full-load torque of the motor. As far as I know this has never been a point of much importance in the motor. Generally speaking, for motor application the starting torque required to overcome the friction of a sleeve bearing is not a matter of importance in the motor itself."

The question was asked as to whether ball and roller bearings are not somewhat uneconomical for the lighter loads and entirely unsuitable for the higher loads where the centrifugal force in the bearings tends to set up greater friction than in the ordinary sleeve type of bearing. In replying to this question, Mr. Hillman said that he had not found it so in experiments which he had conducted. He said: "Ball bearings that run at 15,000 r.p.m. have worked out very satisfactorily and I imagine that if the friction loss in this case was a very great factor, that we would have had difficulty. If the centrifugal force of these balls against the outer race was very great, we would have had a sliding action and burning or heating of the balls, the same as we have when balls become locked in a retainer and spin around as part of the inner race."

Mr. Bley of the bridge department of the City of Chicago raised the question as to what kind of material to use for a bearing which would reduce friction and at the same time be non-rusting. The bearings he had in mind were to be located on a bridge where they would be subject to drippings and to a damp atmosphere and would remain at rest for so long a time that the rust enemy would probably be the one to be the most dreaded. He desired to know if there was a ball bearing made of bronze or some other non-rusting material.

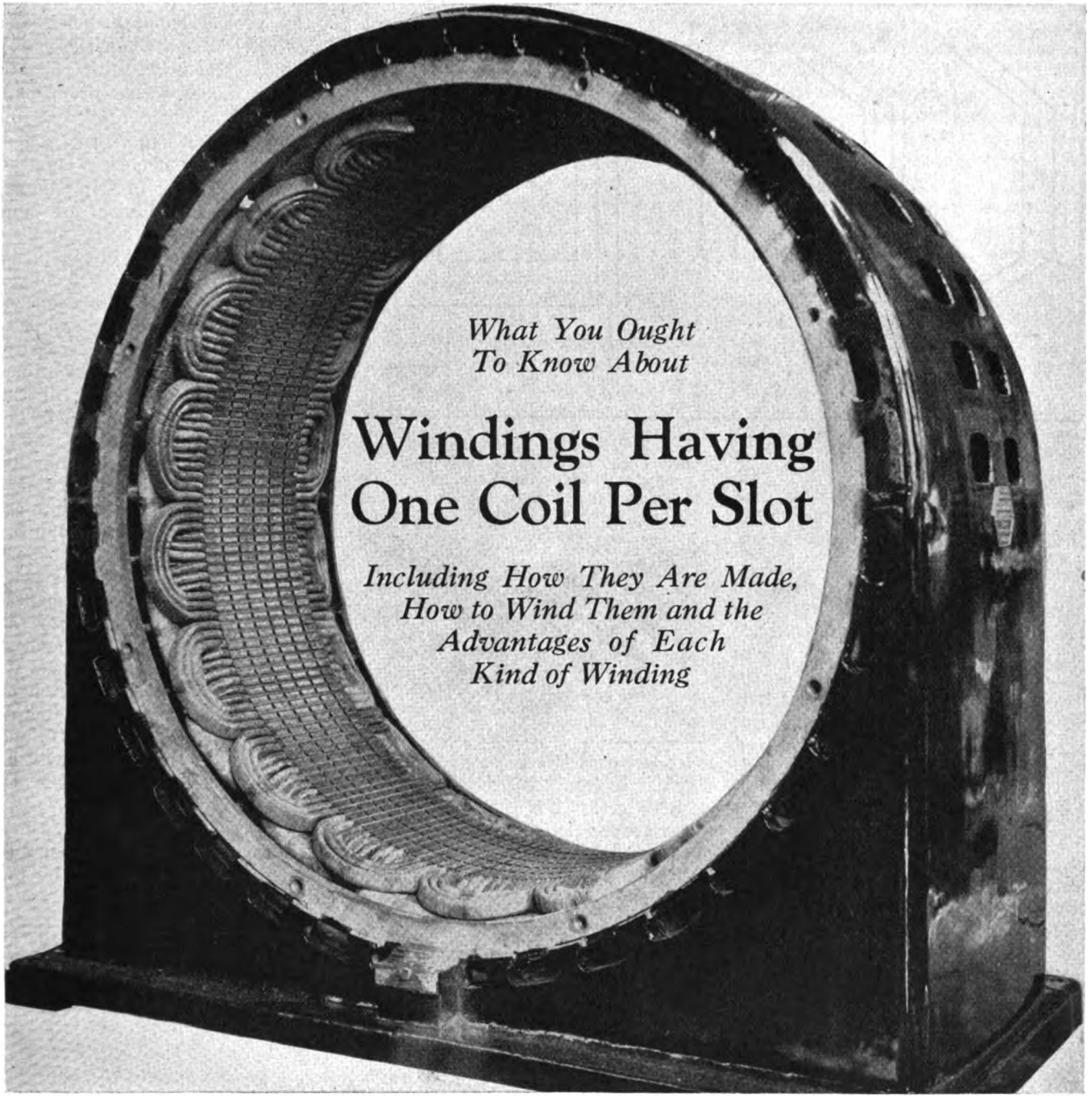
In answering this question, Mr. Williams spoke of an inquiry from an electrical company that desired to use switches out in a marsh where little attention is likely to be given to them and where there is little chance that they will go through without rusting. He said that they had been experimenting with stainless steel to be used in the bearings for the switches. He found that stainless steel would give a hardness that was just under file-hard, and thought that this would be hard enough to give a bearing with a reasonably large capacity and one that would be assured of long life under very severe conditions. He thought that stainless steel offered more possibilities on a roller bearing than on a ball bearing because of the greater contact of the roller on the race than of a ball on its race, which would mean that for the same size bearing a greater load could be carried with less stress at the point of contact.

Mr. Hillman said that there had been some experiments conducted with races and balls made of monel metal or a composition metal which does not easily rust. These were conducted in Sweden and were not satisfactory as bearings so constructed were unable to carry heavy loads.

Trouble arising over the lubrication of ball bearings was another point considered in the discussion. An example was cited of a 2-hp. motor equipped with ball bearings that were entirely enclosed by a casing with felt rings on the side. This motor was running without undue rise in temperature until too much oil was poured in, when the bearing became smoking hot, due to the fact, in the opinion of the speaker, that the balls splashed the oil around and the felt rings on the outside kept the air from circulating. A scheme of maintaining the oil level just at the lower edge of the balls of the bearing was then devised, so that there would be no splashing and yet sufficient lubrication would be provided. With this scheme, the bearing worked perfectly. It was also found that in this particular case the heat generated by the felt washers on the casing of the bearing was considerable, and by taking these out and adjusting them so that they exerted only a light pressure on the shaft, considerable heating was eliminated.

The question was brought up as to whether ball bearings should be run without oil and as to whether they can be run dry for a very long period without undue wear. In answering this question, Mr. Hillman said: "Running bearings dry is a test that was used some years ago, and was called the dry test. It was thought that one of the things necessary for a bearing to do was to be able to run without oil for a period of time. The Bureau of Standards in Washington has made some tests to determine whether the friction in ball or roller bearings is lessened by leaving out the oil. They have reported that they did not find any difference and this has been interpreted as meaning that ball bearings could run without oil. This is not true at higher speeds, although we have an application that ran for 900 hours at 15,000 r.p.m., where only one drop of oil was given to the bearings every hour. The point that has been mentioned regarding fluid friction of a lubricant heating up the bearings is one thing that we are troubled with."

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What You Ought To Know About

Windings Having One Coil Per Slot

Including How They Are Made, How to Wind Them and the Advantages of Each Kind of Winding

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

A WINDING having only one coil side in each slot is known as a one-coil-per-slot winding. Such a winding would, of necessity, be single-layer in the slot section, inasmuch as the slots can contain only one layer of coils. The coil ends, however, may be arranged in two or more layers. One-coil-per-slot windings are used principally on the older types of high-voltage machines.

The most common type of one-coil-per-slot winding is the concentric chain winding. This winding derives its name from the fact that the coils in a group are arranged concentrically with respect to each other, that is, one coil fits inside of the other, and where the coil ends overlap, the arrangement gives the appearance of the links in a chain.

A WINDING having only one coil side in a slot is known as a one-coil-per-slot winding. Of necessity, it must be single-layer in the slot section. The coil ends of the winding may take several different forms: concentric chain, basket, diamond, and involute types being typical. All of these types are described and details for laying them out are given in this article. A succeeding article will treat one-bar-per-slot windings as used on turbo-generators.

Fig. 1—This is a concentric chain winding used on a 400-hp., 6,000-volt, three-phase induction motor.

In Fig. 1 is shown a concentric chain winding for a 400-hp., 6,000-volt, 300-r.p.m., 24-pole, three-phase, 60-cycle, induction motor. The stator has 216 slots and since one coil occupies two slots, there will be 108 coils. As it is a three-phase machine, it will have 36 coils per phase and since there are 24 poles in the ma-

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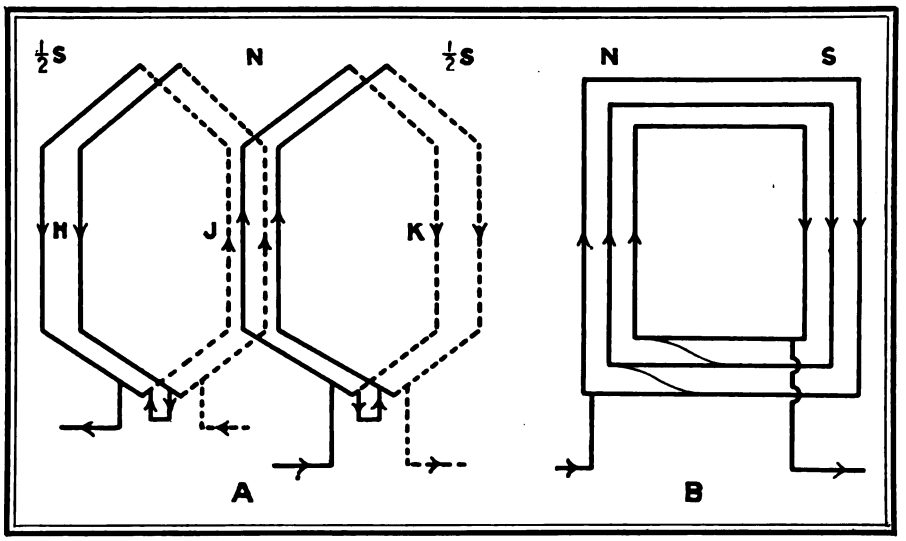


Fig. 2—These diagrams show the difference between a pole-phase group and a dupole-phase group.
In diagram *A* are shown two groups of coils for a two-layer winding. As will be noticed, the two bottom (shown dotted) and the two top coil sides shown at *J* form a full pole while the two top coil sides at *H* form half a pole and the two bottom coil sides at *K* also form half a pole. Hence the two groups of coils form two poles and each group is known as a pole-phase group. In diagram *B* is shown a group of coils for a concentric chain winding. The coil sides at the left form a north pole while the coil sides at the right form a south pole; hence the one group of coils forms two poles and the group is known as a dupole-phase group, that is, a two-pole phase group.

chine, it will have nine slots per pole. Notice how the coil ends are arranged. There are three coils in a group, one coil falling inside of the other; that is, the coils are concentric.

This winding is wound in what are termed two ranges. This refers to the manner in which the coil ends are arranged to pass each other. It will be noticed that the coil ends are in two planes in Fig. 1, and that half of the coils come out of the slot straight, are given a radius, and bent back into the core at a distance of one pole pitch away. The other half of the coils is bent down and the plane of the coil is changed 90 deg. before it is bent back into the core at a distance of one pole pitch away.

In this type of winding, the coils are arranged so that each group of coils forms two poles; that is, it is known as a consequent-pole winding. Hence, there will be one-half as many groups as in a two-layer winding. This is shown in Fig. 2. In diagram *A*, are shown two groups of coils for a two-layer winding. These two groups form two poles; the four coil sides at the center form one pole, the two coil sides at the left form half a pole, and the two coil sides at the right form half a pole. Thus the two groups form two poles and each group is known as a pole-phase group. In diagram *B* is shown one group of coils of a concentric chain, single-layer winding. The three coil sides at the left form a north pole, while the three coil sides at the right form a south pole. Hence, this group of coils forms two poles and to distinguish it from the group shown at *A*, of Fig. 2, it is called a dupole-phase group; that is, it is a two-pole phase group.

In the concentric chain winding previously mentioned, the number of dupole-phase groups will be one-half of the product of the poles and phases; that is, it will equal $(24 \times 3) \div 2 = 36$. The number of coils in series per dupole-phase group will equal the total number of coils divided by the total number of groups. The total number of coils is equal to one-half the number of slots; hence, in this case, the number of coils equals $216 \div 2 = 108$. The number of coils in series per dupole-phase group will equal $108 \div 36 = 3$ coils.

As has been explained, one concentric group of coils will form two pole-phase groups which, of necessity, must belong to the same phase. Since the pole-phase groups fall in the order of the phases as shown in the top diagram in Fig. 3, and since there are three phases, there must be slots enough left inside of the smallest coil of the concentric group to accommodate one pole-phase group for each of the other two phases. Consequently there must be two pole-phase groups inside of the smallest coil of a concentric group. For the winding shown in Fig. 1 the smallest coil must leave six slots between its two sides. Therefore, the pitch of this coil will be 1-and-8; the pitch of the middle coil will be 1-and-10, and the pitch of the outside coil will be 1-and-12. This is shown in the top diagram of Fig. 3.

A two-layer winding for this machine would have a coil pitch equal to the number of coils divided by the number of poles; then $216 \div 24 = 9$,

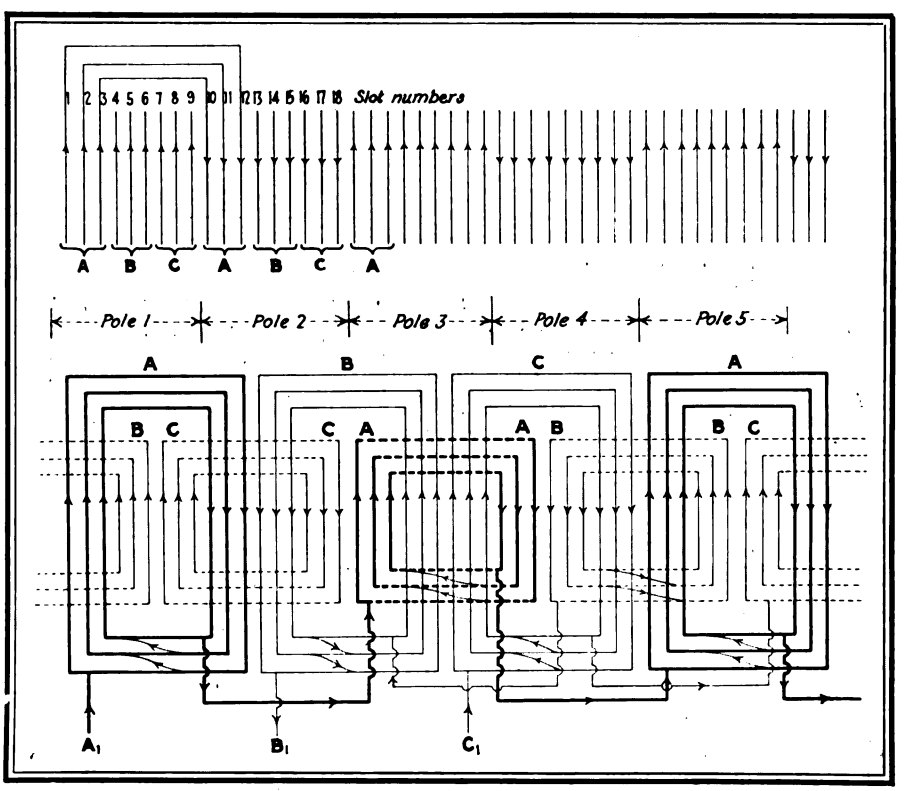


Fig. 3—Here is the connection diagram for the concentric chain winding shown in Fig. 1.
This winding is two-range, as can be seen from the two shapes of coils that are used.

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or a pitch of 1-and-10. This is 100 per cent pitch. Consequently, since the middle coil of the concentric chain winding has a pitch of 1-and-10, it has full or 100 per cent pitch; the inside coil is chorded one slot under-pitch and the outside coil is chorded one slot over-pitch. The chord factor, however, of both the inside and outside coils will be the same, for the average pitch is $(7+9+11) \div 3 = 27 \div 3 = 9$, or a pitch of 1-and-10.

In laying out a winding similar to the one shown in Fig. 1, lay out slots enough for, say, five poles, as shown in the top diagram of Fig. 3 and mark the arrows on each pole group so that the polarity of each pole group will alternate, as shown. Since we know the pitch of the coils, we may draw in the first concentric group of A-phase coils, as shown in the diagram. We will take the first pole-phase group of each pole, shown at the left in both diagrams in Fig. 3 as having coils that come straight out of the slot and are not bent down. The outside coil will be the start of the A phase, as shown at A_1.

Slots *4*, *5* and *6* will be occupied by the B phase and slots *7*, *8* and *9* will be occupied by the C phase. Knowing the pitches of all of the coils, the coils may be sketched in the order shown in Fig. 3. Since slots *1*, *2*, *3*, *10*, *11* and *12* are occupied by straight-out coils, slots *4*, *5*, *6*, *7*, *8* and *9* must be occupied by bent-down coils; that is, coils of the second range. From the diagram you will notice that the straight-out coils fall in the order A, B, C. The same is also true of the bent-down coils.

We have started the A phase at A_1. We may start the B phase in the next pole at B_1 and the C phase in the third pole at C_1. This will give us two phases with current leading into the winding and one phase with current leading out as is shown by the arrows on the leads in Fig. 3. This is the two-in-and-one-out check which all three-phase developed windings must meet.

In connecting the individual coils, the outside coil should be connected to the middle coil, the middle coil to the inside coil, and the inside coil is then connected to the outside coil of the next dupole-phase group for that phase.

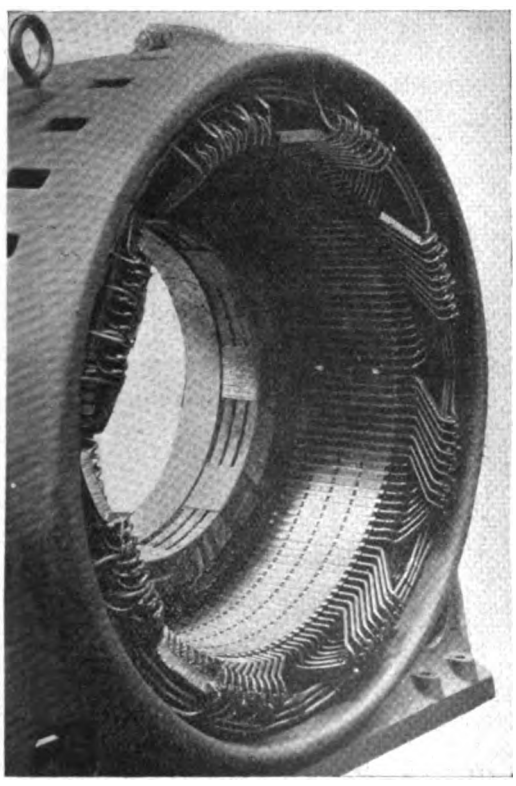
With concentric chain windings having an odd number of groups, it is necesary to use a specially-shaped group of coils. Take the case shown in Fig. 5. This is a three-phase, 14-pole stator, having 210 slots and 105 coils. This winding has 15 slots per pole and, $(14 \times 3) \div 2 = 21$ dupole-phase groups. There will be $105 \div 21 = 5$ coils per dupole-phase group. Hence, the pitch of the inside coil of a concentric group of coils will be 1-and-12. In Fig. 5 there are twenty concentric groups of coils in place. Ten of these groups are made up of coils having bent-down ends and ten having ends which are in the same plane as the coil sides. At the lower left of Fig. 5 there are two places where five slots have been left empty. Coils having coil ends in the same plane as the coil sides cannot be used here as they would obstruct the unconnected coil group falling between the two sets of empty slots. Coils having bent-down ends, the same as the others, could not be used, for they would obstruct the adjacent, bent-down group of coils. Hence, to fill these slots, coils having specially-shaped ends must be used.

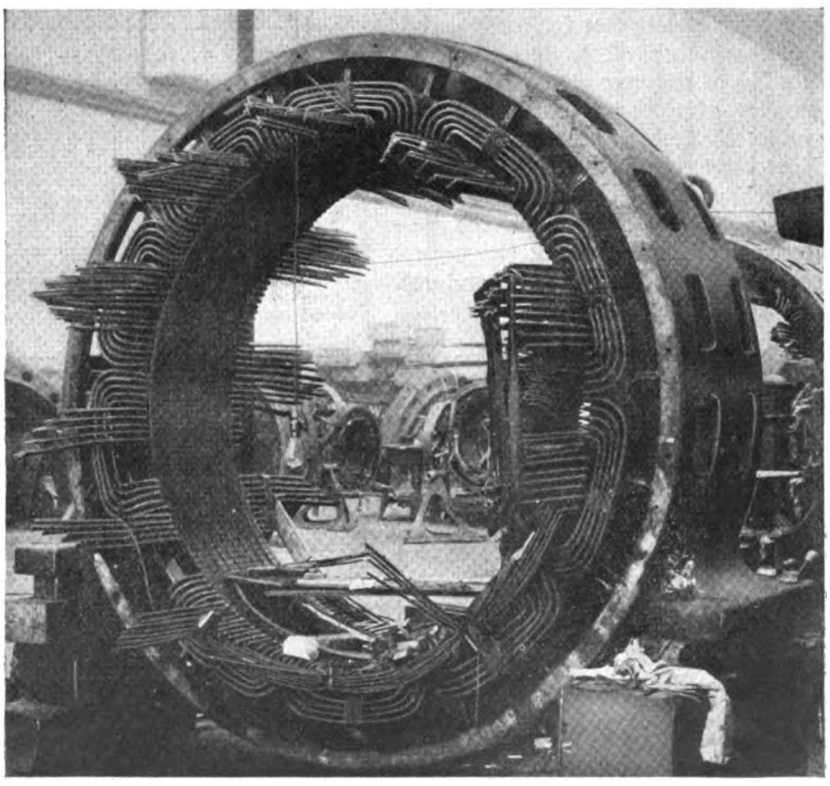
The winding shown in Fig. 5 is termed a "shoved-through" type, two-range, concentric chain winding. Five different sizes of molds are required for this winding. Ten groups are shoved through from one side of the stator and ten groups from the opposite side. The free ends are then formed and connected together on the stator, as shown in the lower part of Fig. 5.

The only advantage of this type

Figs. 4 and 5—Diamond-shape winding and shoved-through type concentric chain winding.

The winding shown on the left is for three-phase service and has 16 poles, 144 slots, 12 coils, with three coils per dupole-phase group. Each group of nine coils shown forms two poles. The machine on the right has a shoved-through concentric chain winding. The coils are shoved through from one side of the stator and the free ends formed and connected as shown in the lower part of the illustration. This machine is three phase and has 14 poles, 210 slots, 105 coils and 21 dupole-phase groups. A special or bastard group is to be placed in the empty slots in the lower left of the illustration.





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of winding is that it can be well insulated on the ends. This, however, is more than offset by the expense involved in making the number of different sizes of molds required for winding the coils and by the labor required in placing the coils in the stator and connecting them up. Another disadvantage is that this type of winding cannot be readily adapted to changes in the number of poles or phases.

For example, take the case shown in Fig. 6, which is a three-phase stator having 96 slots, 16 poles, 24 dupole-phase groups of two coils per group, and two slots per pole per phase. If we wanted to use this frame for a 12-pole winding, it would necessitate leaving a few slots idle, as there would be $(12 \times 3) \div 2 = 18$ dupole-phase groups and with 48 coils there would be $48 \div 18$ groups, which gives us 12 groups of three coils and six groups of two coils. Odd grouping cannot be used, however, and therefore it would mean killing 12 coils. This is a loss of 25 per cent and consequently the 12-pole winding would not fit. Again, assume that we desired to use this stator for a two-phase 14-pole winding. There would be $(14 \times 2) \div 2 = 14$ dupole-phase groups. Dividing 48 by 14 gives us 14 groups of three coils with six coils left over. Hence we would have six dead coils. Here again this change could not be satisfactorily made.

From the above it follows that to construct a diagram for a concentric chain winding, first, determine the number of groups; then calculate the number of slots per pole per phase, and finally find the number of ranges. Next lay out about four or five poles as is shown in Fig. 3, place arrows on the coils so as to form the pole groups and then connect the groups together using the two-in-and-one-out method mentioned before.

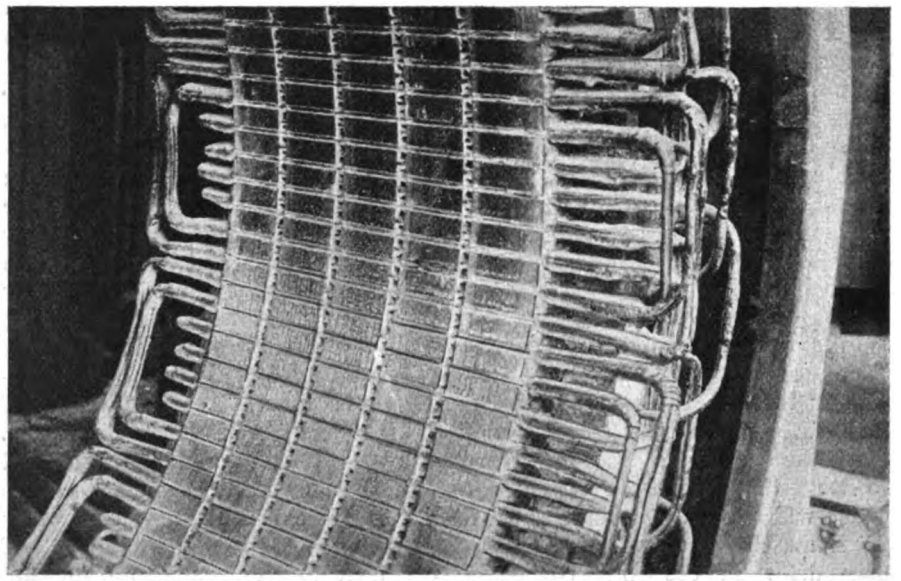


Fig. 6—Here is another shoved-through type of concentric chain winding.

The advantage of this winding is that it can be well insulated on the ends.

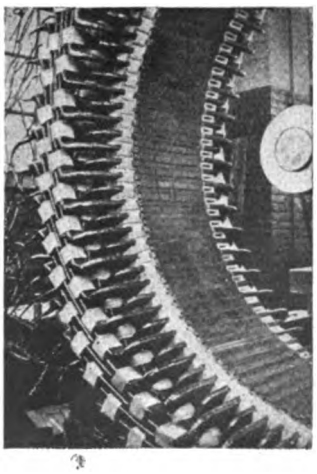
Another form of one-coil-per-slot winding is called the basket winding. In this winding the coils are all of the same size and are shaped while winding. The coil ends cross each other by the most direct route in smooth regular curves. The interweaving of the coil ends gives the winding an appearance similar to the weave of a basket, hence the name.

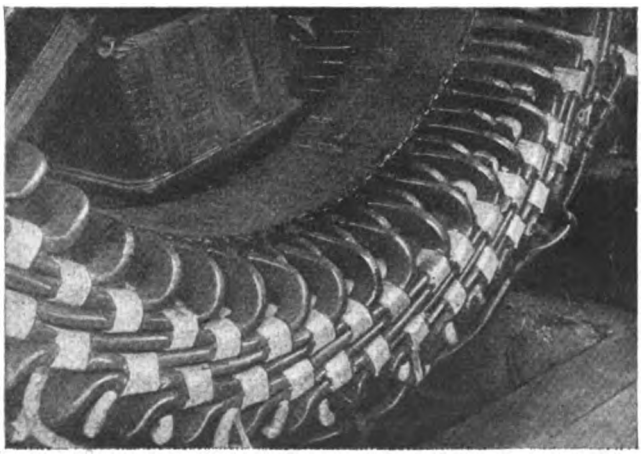
Still another form of one-coil-per-slot winding is the diamond-shape type shown in Fig. 4. This winding has 144 slots, 72 coils, 16 poles and is intended for three-phase service. The winding is wound with consequent poles; hence each group of coils forms two poles as has been explained previously in this article. It will be noticed that the coil sides which connect to the ends on top form one pole and the opposite sides of the same coils which connect to coil ends overlapped by the above mentioned coil ends, form another pole. In other words, each group of nine coils forms two poles; consequently, there will be three coils per dupole-phase group. The coil pitch depends upon the number of slots per pole.

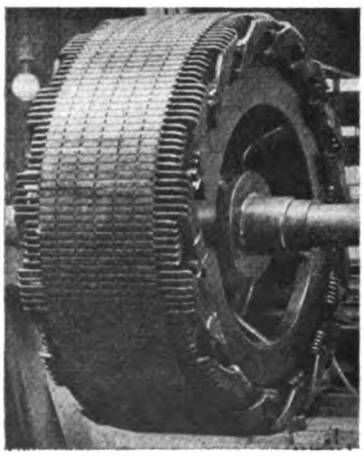
The advantages of the diamond-shape coil are as follows: A form may be made so that it can readily be adjusted for different sizes of coils; the coils can be easily insulated and assembled; repairs to damaged windings can be made with small expense; the winding can be arranged and connected in nearly any manner; the connection may be readily changed to suit different conditions; for a certain machine the coils may be alike. (*Continued on page 47*)

Figs. 7 to 9—Here is an involute type of one-coil-per-slot winding.

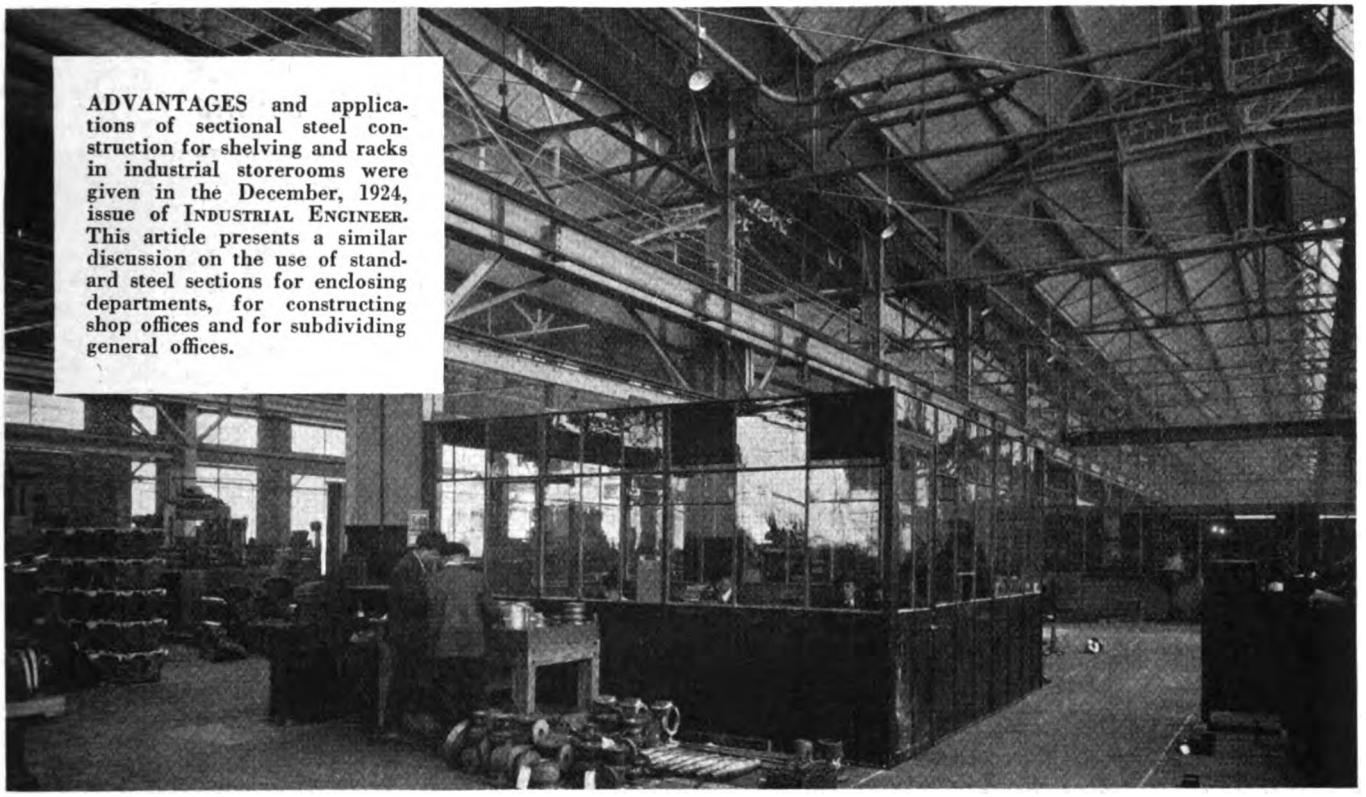
Fig. 7 shows an involute winding in place ready to connect. Fig. 8 shows the winding stubbed and connected. Fig. 9 shows an involute winding for the rotor of a large induction motor. This rotor has 90 slots, 45 coils, 10 poles, with 15 dupole-phase groups of three coils each. Notice that in all of the illustrations, one coil side is shorter than the other for the same coil. As can be seen the short bar connects to the bottom coil end and the long bar connects to the top or overlapping coil end.







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ADVANTAGES and applications of sectional steel construction for shelving and racks in industrial storerooms were given in the December, 1924, issue of INDUSTRIAL ENGINEER. This article presents a similar discussion on the use of standard steel sections for enclosing departments, for constructing shop offices and for subdividing general offices.

This factory office is adopted as standard in this plant. Here it is located under a craneway and so is roofed over for the sake of safety.

Some Details On the Use of

Industrial Partitions in Office and Factory

For Erecting Enclosures Around Departments and for Isolated Offices, Such as for Foremen and Timekeepers, as Well as for Subdividing Large Areas into Offices or Small Rooms

By FRANK E. GOODING
Associate Editor, Industrial Engineer

MODERN industrial plants are under an intermittent process of making changes and rearrangements in layout. Fluctuating production demand, new or discontinued products, or changes in methods or processes, cause increases or decreases in the space required and in many cases an entire shifting of machines and sometimes of whole departments.

Industrial men have found that this occurs so frequently that it is desirable to use partitions which may be taken apart without damaging them and again erected in a new location. Wood was first used for this purpose, but because of the numerous advantages of steel, as will be pointed out later in this article, a large proportion of these are now made of steel or wire and often provided with glass panels, doors and transoms. Some wooden partitions are made in sectional units but these are generally used in offices and do not stand up under the hard knocks they receive in industrial service. A hard bump with a loaded truck would crush them. Also, in most industrial works it is desired to have as little wooden construction out in the plant as possible because it adds to the fire hazard. This hazard is increased due to the possibility of oily waste or rags being accidentally left in contact with the wooden partition.

Steel partitions have many of the same advantages given for steel in the construction of factory shelving, as indicated in the article on, "Shelves and Racks in Industrial Storerooms," which appeared in the December, 1924, issue of INDUSTRIAL ENGINEER. One of the first and most important advantages of steel construction for partitions is its ability to resist fire. Steel is not only noncombustible but it will often retain a fire in a closed office until it has burned itself out. Also, where sprinklers are installed, all fire and water damage is confined to the one location. Where the building has a sprinkler system at least one sprinkler-head is required in each enclosure. Steel partitions will not absorb oil, turpentine or paint as will wood and so do not become hazardous.

Perhaps the next most important advantage of steel lies in the possibility of unit construction which enables whole sections to be assembled with doors, glass or wire panels, or transoms as desired. This unit construction enables the partition to be salvaged by taking it apart and using it again when necessary to make any rearrangement. Also, these units can be fitted together to fill almost any opening.

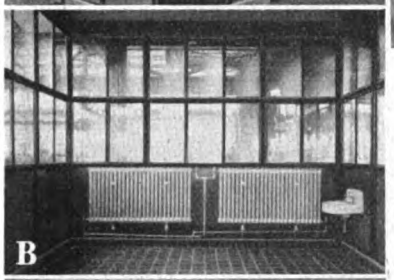
Another advantage is that steel is

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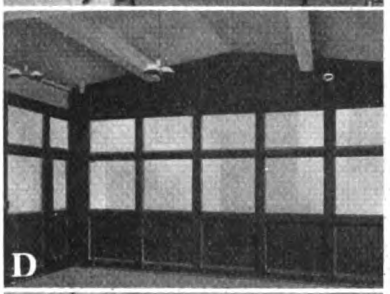
Typical Applications of Standard Steel Partitions

Examples Taken from Thirteen Industrial Plants


A

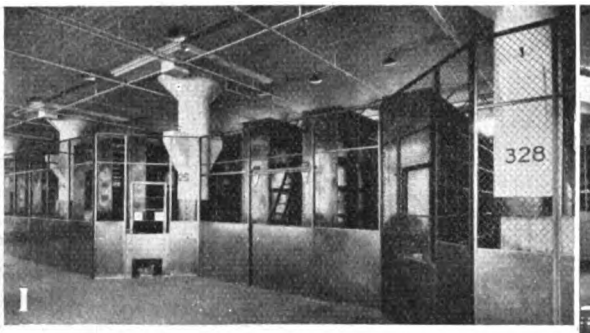

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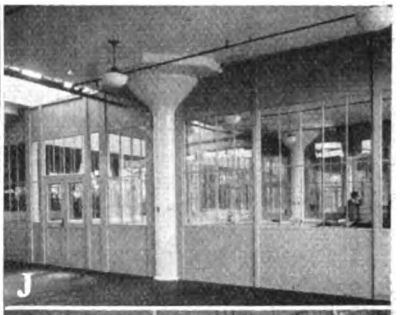

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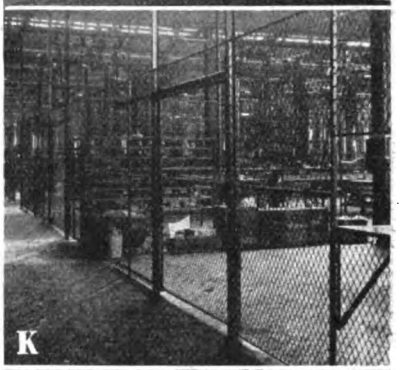

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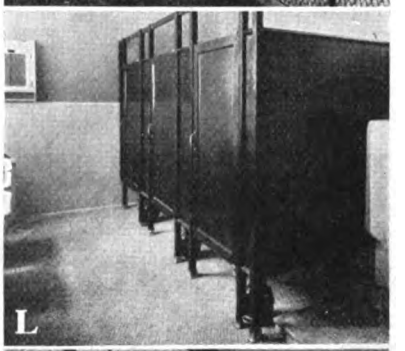

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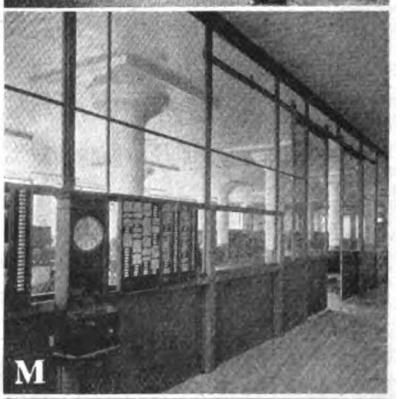


I


J


K


L


M


N

A and B—Exterior and interior views of the standard mill offices used at the Lorain, Ohio, plant of the National Tube Co.

C—Notice how the standard units fit around a column and pilaster cap. The large glass area in the partition units gives considerable light through a double row of offices.

D—The space between tops of partitions and irregular-shaped ceilings is filled in with special plates.

E—Wire mesh partitions may be used as backs to shelving in order to let more light through. Note the cross bracing necessary when backs are omitted.

F—A neat arrangement of individual offices made from standard units.

G—This industrial recreation room is built up of standard steel-and-glass units.

H—The wire mesh partitions around the stockroom permit the same heating and ventilating units to heat both stockroom and factory.

I—Note here the sliding door, the receiving wicket and also the swinging floor opening for receiving or issuing tote boxes.

J—A neat method of fitting the partitions around the flaring top of the column. The double door may be obtained in most types of standard equipment.

K—Another wire-mesh-enclosed stockroom with several subdivisions.

L—Special rustproof partitions used in factory toilets. Similar partitions are sometimes used around showers. Standard steel units are used for the enclosing walls.

M—Here a combination of steel units and wire mesh is used. Notice also the large double sliding doorway.

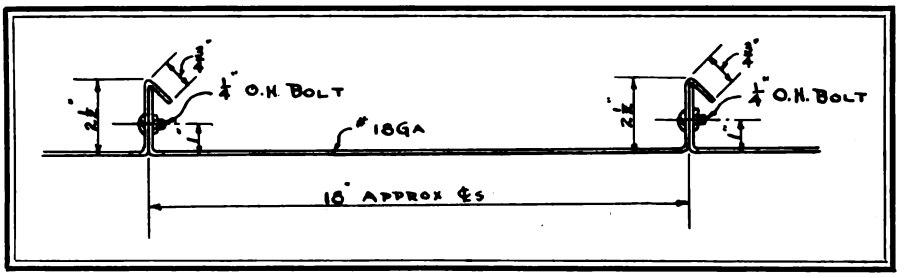
N—This application of wire mesh units closes off a stairway.


G


H

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How small offices are roofed over.
This is one type of standard steel section used for roofing over small offices. These do not need any support except at the end when standard steel sections are used, unless the office is wider than 10 ft. If glass in units is used, the permissible width between supports is 8 ft. Frequently it is possible to support the roof from the ceiling of the main building, as is shown in the two illustrations at the bottom of the page.



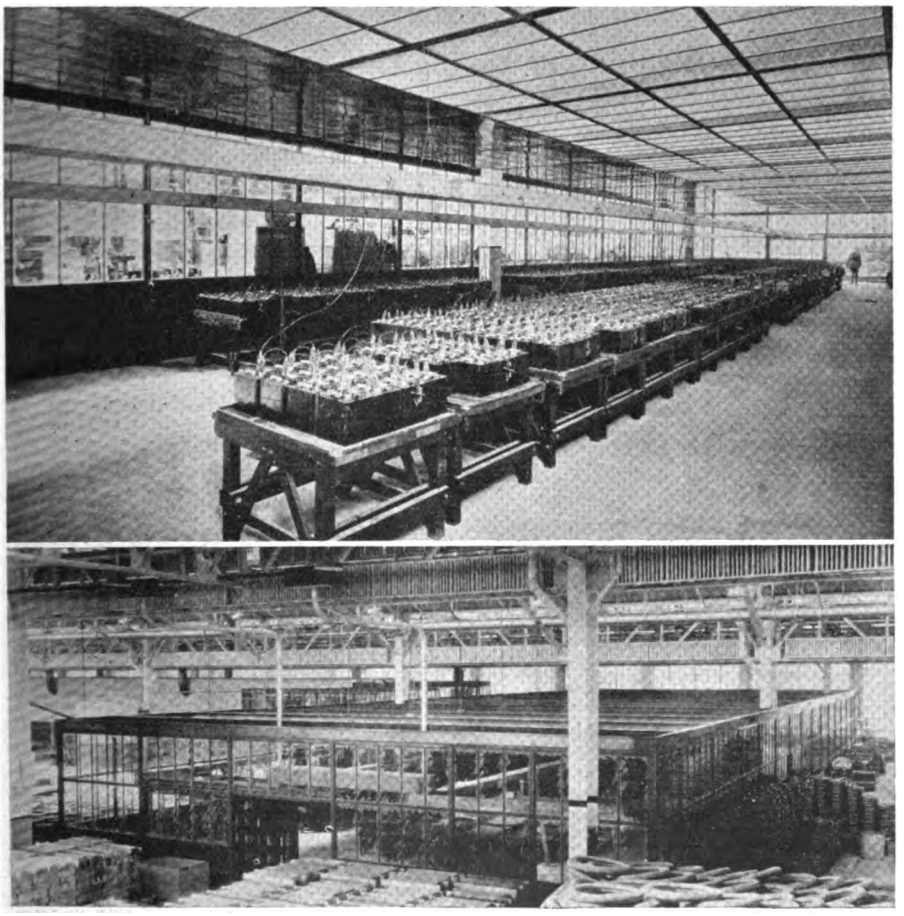
easily painted or enameled and carries a good finish. Some of the manufacturers of these partitions supply them with only a priming coat for protection during shipment and the user paints them any color desired. Others supply them in a more highly finished enameled coating. Also, steel is easy to clean and keep clean. Its strength is an important consideration when used in an industrial plant, for although a partition may be sprung when bumped, as by a loaded truck, any permanent indentation may be straightened out for the sake of appearance. These bumps may interfere somewhat with dismantling but they could be straightened out again before reassembling.

Modern factory buildings are often erected with large, open floor areas. Frequently, no actual division walls are placed between departments. A large open area is usually easier to heat and ventilate than are smaller subdivisions. In addition, it would hardly be practical to build in many permanent walls because of the difficulty in deciding exactly where they should be. This has led to the wider use of steel unit partitions.

These are used for three general purposes: (1) Foreman's or timekeeper's factory offices; (2) Subdividing main factory or general offices; (3) Separating departments, such as enclosing stockroom, toolroom and similar places.

Since management has begun to exercise more careful control and supervision over the workers and their jobs, it has become necessary to maintain larger departmental offices distributed about the plant. These are for the foremen, timekeepers and also for handling the assignment of jobs to workers. Unit steel sections are easily adaptable for this purpose, as is shown in the illustration at the head of this article. Here the door unit is the same size as a wall section and so can be inserted anywhere in the wall. Also, here, as in many other cases, it is necessary to cover the office to keep out dirt and noise and also make it easier to heat for the benefit of those who must remain inside all the time and so require a higher temperature than the factory workers who are more active. Very frequently, a few girls are employed in these offices. In such cases, more adequate provision for heating is necessary. Ordinarily, steam is used if available. However, many warehouses are not heated. In such cases, a small office such as this may be most economically heated by unit electric heaters, as electrical energy can be carried any reasonable distance with practically no loss and at much less installation expense than for a steam unit. Lines carrying steam several hundred feet, as is sometimes necessary, would have a larger loss in the radiation of the line than would be required to heat the office.

Frequently, it is desirable to add some facility for ventilating the shop offices which are covered over. This is not always done, however. One way to do this is by the use of transoms or upper sashes which may be opened. These, however, open up the enclosure to noise and dirt. Another way is to use a fan ventilator set in a panel or a small blower to exhaust the air from the room. Often it is not necessary for the office to be covered over. However, when under a craneway, as in the illustration at the head of this article, it is much better from a safety standpoint to cover it. Many manufacturers of partitions will provide unit sections of metal or glass, or in combination,



A large room is constructed of standard steel units and roofed over.
This battery room is erected inside a branch factory of a large automobile manufacturer. Here it was necessary to roof the enclosure. This was done by using standard steel sections and some glass sections, which enabled the room to be lighted by "borrowed" light from the skylight of the main building. These glass sections are suspended from the ceiling of the main building.

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which may be used as a roof. In buildings with low ceilings, the partitions may be extended clear up to the ceiling. After the partition units are run up to the full height the space between the top rail and the ceiling is filled with a special plate which may be cut to fit around cornices, columns or beam ceilings.

Steel partitions are becoming more commonly used in laying out general or factory offices in connection with industrial plants because alterations are perhaps more frequent in office layouts than in the plant itself.

Several arrangements of these steel partitions for offices are shown in some of the accompanying illustrations. In buildings with ceilings of ordinary height the partitions often are extended to the ceiling. However, they are frequently stopped about a foot or two below the ceiling so as to provide for ventilation. At this height, the partitions do not allow voices to carry over objectionably from adjoining offices. Where partitions do not reach the ceiling, a special cornice or head rail in long lengths is used on the top. With these lateral or ceiling braces are usually not necessary unless a wall extends over 20 ft. in length.

Although it is not always necessary to separate or enclose departments, it is very desirable at times, as in the case of toolrooms, stockrooms, experimental or new development departments, and laboratories, plating rooms or other departments which give off fumes or odors. Some of these need tight enclosures while with others the partitions need not extend to the ceiling. In some cases, it is even more desirable to have a partition of wire mesh above the lower panel to aid ventilation and the distribution of heat. Also, in some cases wire partitions are used to aid in the distribution of light. A steel mesh can be obtained in place of glass panels in almost any type of partition. Mesh is also used around tool and other supply wickets. Each manufacturer of steel partitions offers various types of wickets, some of which are shown in the accompanying illustrations.

Laboratories and similar departments producing fumes or odors are usually in rooms with low ceilings. The partitions can then be extended all the way up. However, when it is necessary to place them in large, open rooms with high ceilings the enclosure must be roofed over. How this is done in the battery room of a branch factory of a large automobile manufacturer is shown in the illustrations and sketch shown on the previous page. This is an exceptionally large room and the side walls were erected complete from a standard partition unit.

The roof was assembled partly from glass units and the balance of steel. The entire room is clear of posts or uprights. For assembling the roof lightweight steel beams or supporting bars extending across the roof were anchored into the partition posts and were held up by support bar hangers suspended from the roof of the main building. The glass panels in the roof of this battery room enable advantage to be taken of the natural illumination received through the skylight of the building. If it should become necessary at any time to change this battery room, it can be taken down and re-erected in some other part of the plant, or even in another plant without any additional cost except labor cost.

The method of constructing a roof for a smaller shop office is shown in the accompanying sketch. In the assemblage of the steel roof as shown in the detail sketch, sheets are cut approximately 18 in. wide and are curved up, lapped over and bolted together with ¼-in. bolts. This construction is strong and sturdy and can be used without support bars of any kind up to a width of 10 ft. This, of course, holds good for any length of room. However, roofs which are assembled from standard glass units can be constructed without support bars of any kind up to a width of 8 ft. In shop offices of larger size where the roof cannot be self supporting, this roof surface may be supported from the ceiling with hanger rods, as is indicated from the illustration of the large battery room.

In erecting partitions the main requisite is to follow the directions of the manufacturer and to be sure that sections are vertical, that the floor is level, or that the partitions are blocked up so that they fit together securely both horizontally and vertically and that they are fastened together properly. Otherwise, due to improper construction and forcing these sections together, some section may be put under a strain which may interfere with dismantling them; also if they are strained (*Continued on page 46*)

Information Necessary When Planning or Laying Out Steel Partitions

These ten questions, which are used by one manufacturer in preparing estimates, will also be valuable to the prospective user in determining some of the points to consider when planning an installation.

(1) **Floor plan showing columns, walls and windows or mullions adjoining partitions, also location of doors in partitions and direction in which they are to swing.**
This floor plan must show dimensions, and state whether they are exact or approximate. Often a small change in layout will permit standard units to be used at a considerable saving in cost.

(2) **Is the floor wood or masonry?**

(3) **Nature of walls (brick, plaster, etc.).**

(4) **Are wall surfaces, into which partitions run, straight or irregular up to the height of the partition head rail?**
If irregular, it is usually necessary to place the nearest mullion a short distance from the wall and fill the intervening space with a flanged steel filler plate cut to fit the wall. The same applies to columns.

(5) **Is the partition to be open or closed above the head rail? If closed, state exact distance from floor to ceiling.**
Partitions that meet the ceiling cost much more to make and fit than when a space (say 1 ft.) is left. This space makes little difference in sound transmitted; it gives clearance for sprinkler pipes, etc., and it is valuable for ventilation.

(6) **Must partitions meet window mullions?**
If so, furnish a sketch of vertical profile, so that a steel plate can be cut to fit the desired contour.

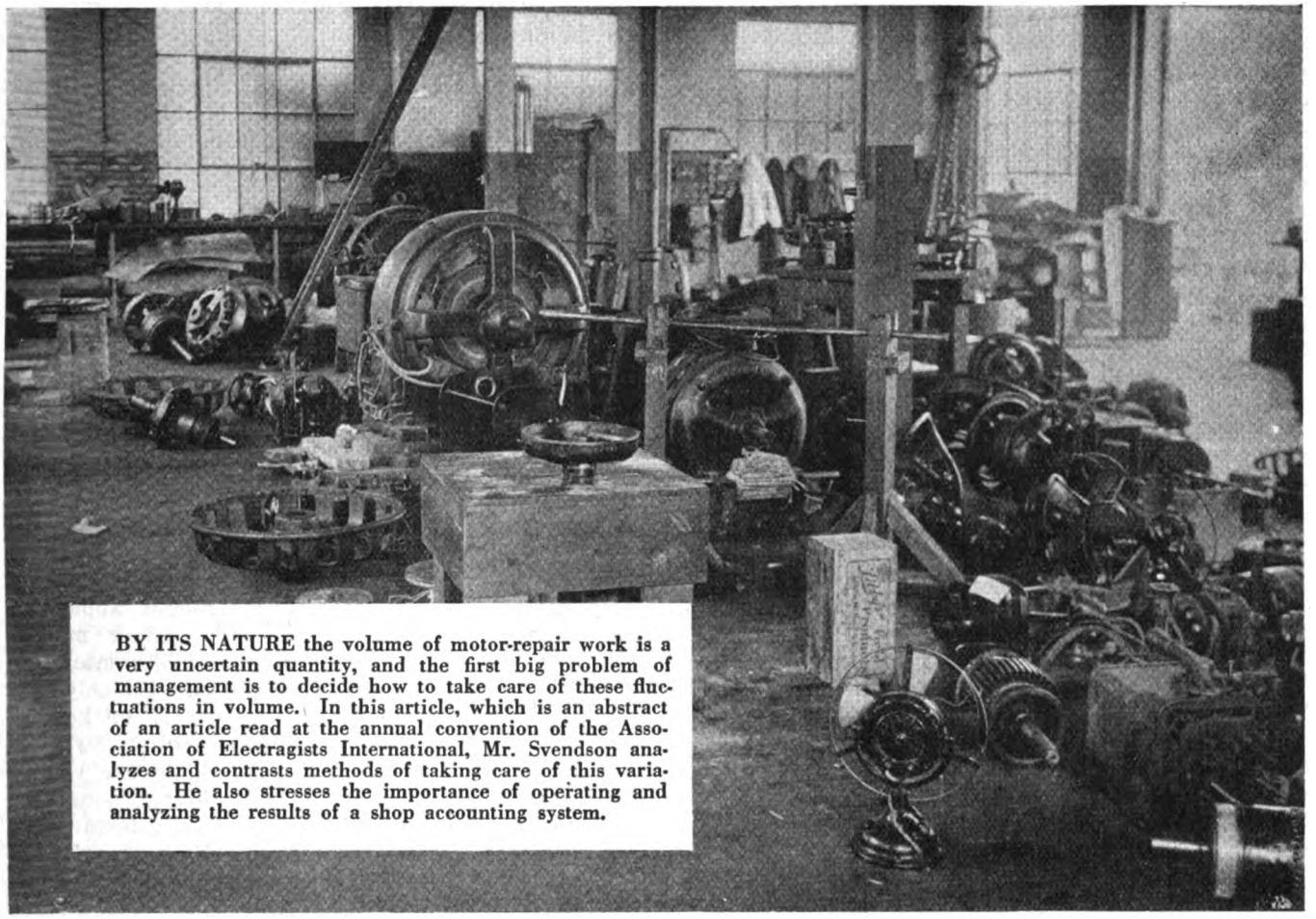
(7) **Specify desired height of base plate.**
This should preferably be the standard height for that type of partition; but it may be desk height (32 in.), or some other height, at additional cost.

(8) **Minimum door opening allowed.**
See catalog for standard door openings. Occasionally wider doors are necessary to accommodate furniture or shop articles.

(9) **Specify kind of glass desired.**
Wire grills or screens will be furnished if specified.

(10) **Hardware should be specified in detail.**
Standard equipment should always be used. For interior partition doors, locks and latches are usually unnecessary. A door check and pull handle are better. Where hardware is not specified we furnish such doors with hinges and pull handle, but not with door check. Outside doors will be furnished, on specification, with cylinder locks to fit customer's master keys.

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BY ITS NATURE the volume of motor-repair work is a very uncertain quantity, and the first big problem of management is to decide how to take care of these fluctuations in volume. In this article, which is an abstract of an article read at the annual convention of the Association of Electragists International, Mr. Svendson analyzes and contrasts methods of taking care of this variation. He also stresses the importance of operating and analyzing the results of a shop accounting system.

One of the best solutions of the variable-volume problem in conducting a repair shop, is to take up the rebuilding of used electrical apparatus. By doing so, an organization can be maintained to give peak repair service at all times, and when the repair work drops off, the same shop crew can be used for overhauling and rewinding used machines.

Business Viewpoints on

Operating and Managing Motor Repair Shops

Together With Ways of Handling a Fluctuating Volume of Work, Importance of Proper Accounting, and Stores Control of Repair Parts

By GEORGE P. SVENDSON
President, Boustead Electric & Mfg. Co., Minneapolis, Minn.

ORIGINALLY, the motor-repair business was operated as a sort of necessary evil in connection with electrical contracting and it is even today considered by many Electragists as an unprofitable branch of their business.

But of late years, the use of electrical power equipment has grown by leaps and bounds and the old type of motor-repair shop has found itself unable to take care of the increased business. This has resulted in a great many establishments devoting a substantial part of their efforts to work of this character.

By its nature the volume of motor-repair business is a very uncertain quantity, and the first big problem of management is to decide how to take care of these ups and downs of volume. They are not seasonable to any great extent, nor can prediction of them be based on past experience since they originate in accident, misfortune and carelessness, which have no rule or law to govern except the law of averages. This law of averages will only help when the territory served is increased and hence points to one way of carrying on an exclusive motor-repair business: namely, *to go after it in a big way and cover a large territory geographically.*

Prompt and efficient service is the foundation of a successful repair shop and with a widely fluctuating volume of business such service cannot be maintained without a working force and equipment based on practically the peak load.

At first thought it would seem that an ideal combination would be to operate the motor-repair shop in connection with the regular electric contracting business. A careful analysis of such a combination shows it to be a poor one at its best. Such combinations, indeed, are responsible for the many statements that the motor-repair business is not profitable.

In the first place the men required for the two classes of work need

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entirely different training. Your shop mechanic usually makes a poor wireman and the average journeyman is lost on the simplest rewinding job.

In the office, likewise, the training required is different. The repair-shop office man must be trained along more strictly engineering lines and be well up on electrical and machine design as well as on shop production methods. In addition the equipment and materials used are distinctly different.

Some may dispute the above claim and point to successful firms carrying on both lines of work, but it will usually be found that such firms are either operating with distinct and separate departments, each complete in itself, or one department is suffering at the hands of the other.

One of the best solutions of this variable-volume problem is to take up the rebuilding of used electrical apparatus.

In this way an organization can be maintained to give peak repair service at all times and when the repair work drops off this same shop crew and equipment can be used for overhauling and rewinding used machines. Likewise in the office the switch can be made smoothly and efficiently. There is engineering work in remodeling or changing the design of old machines; there are stock lists and advertising to be looked after and the selling and rental of this equipment is highly profitable.

Of course other lines can be added, such as new motors and control apparatus, with allied supplies, such as pulleys, fuses, belting, shafting, etc., but so far as the shop proper is concerned there is nothing like the rebuilding of used machines to act as a sort of storage battery to consume the surplus productive power of the repair department.

In some cases where plenty of capital is available the rebuilt machines may become the dominating feature of the business, but at any rate the two go hand in hand and make the ideal combination.

On this basis let us briefly consider some of the more important points of general business principles as they apply to a motor-repair shop as outlined in the Electragists' pamphlet by Lawrence W. Davis.

One of the most important of these is accounting. To run a motor-repair shop without an adequate accounting system is simply courting disaster. Above all things use an accounting system after it is installed. There is nothing like making monthly and yearly comparisons of sales and gross and net profits as well as departmental comparisons. It shows the leaks and indicates where and when to put on special effort.

Many interesting and sometimes startling facts can be discovered by comparing various monthly or yearly totals. For example: Shop overhead compared to total productive man-hours; general office overhead compared to number of sale tickets put through; store-room expense compared to number of items handled, etc. Many Electragists put in a system and forget it except to get a final profit-and-loss statement at the end of the year, whereas such a system contains a mint of information that if properly analyzed and used will make for more business and better profits.

IN EMPHASIZING the importance of accounting in motor-repair shops, Mr. Svendson makes the following statements:

"To run a motor-repair shop without an adequate accounting system is simply courting disaster. Above all things use an accounting system after it is installed. There is nothing like making monthly and yearly comparisons of sales, and gross and net profits as well as departmental comparisons. It shows the leaks and indicates where and when to put on special effort.

"Many interesting and sometimes startling facts can be discovered by comparing various monthly or yearly totals. For example: Shop overhead compared to total productive man-hours; general office overhead compared to number of sales tickets put through; store-room expense compared to number of items handled."

In the motor-repair business practically all the work is done on a time and material basis; so it is absolutely essential that overhead be properly charged to each job. A good accounting system is the first step to secure this result.

One important point often overlooked by repair shop men is the proper basis of figuring allowances on old apparatus when taken in trade for new or rebuilt machines.

If an accurate account is to be kept of the profit on rebuilt machines it is essential that some system be installed to keep tab on the value of such stock.

One of the best schemes is to use an individual stock card for each machine, giving its complete technical description and its "trade-in" or "cash purchase" value. In addition, the cost of rebuilding should be shown. In this way an exact inventory record is always available and the cost value of the rebuilt apparatus can be accurately determined.

Without such a system the year's profit-and-loss statement will mean nothing, as the pricing of the rebuilt machine stock will be subject to personal judgment and if priced above the actual cost will show a paper profit which has not been realized and on which taxes will have to be paid. On the other hand if priced below the actual cost, a paper loss will be shown that will be misleading and reflect in disproportionate profits later.

While there is a sort of market selling price on rebuilt apparatus there is no corresponding market cost, as so many variables enter into the matter. Therefore, the only safe procedure to follow is to keep a record of the actual cost.

Where used machines are rebuilt by a repair crew in odd hours between jobs, it is advisable to carry the cost of rebuilding into the inventory without overhead added. Experience will usually show that rebuilding in this manner will cost appreciably more than where the work can be put through on a steady production basis. The total overhead can be charged to the repair work, which is proper, as without the rebuilding work the overhead would not only be as much but actually more by the amount of idle time between jobs. Of course where the rebuilding is the main issue and repairs are incidental the above would not apply and the overhead would have to be applied to rebuilt machine costs in some proportionate manner.

Another important feature of the motor-repair shop is the maintenance of proper stocks of material and finished merchandise.

The contractor-dealer can depend considerably on his jobber for his material, but with the exception of some of the larger cities we find very few jobbers that carry any stock of material such as required by the repair shop. This means that the repair man must maintain his own stocks and as the service he renders depends vitally on this stock it is very important that it is kept up. One of the best methods of doing this is by the use of a perpetual card inventory. This sug-

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gestion is sure to meet with opposition, and rightly so, if the system put in is top-heavy and not adapted to the business.

Now here is the secret of the success of a stock-card system for a small repair shop, especially where practically every job must be priced on account of time and material billing: First, put all material in a locked stock room with one boy or man in charge and responsible. Material should be issued only on requisition, using a small slip with a place to check deduction from stock and charging to job. The stock card should also be a price card so that in one operation the stock man deducts the quantity from stock and gets the cost price on the requisition slip. The slip next goes to the office to be filed in the job envelope or posted to the job ticket. The usual objection to the stock card is on the grounds of extra work and extra help, but if the old system is analyzed it will be seen that the same or more work is being performed and with less efficiency. In our old system the shopmen laboriously recorded material that is now quickly and accurately done by the stockman. In the old way a clerk priced a mixed list in a slow and inefficient manner. Now the stockman gets the price instantly from a ready card and at the same time with little extra effort strikes a new balance. Instead of a large number of stock clerks so to speak, each working a few minutes a day, we have only one who works efficiently. Where the stockman would not be kept busy all day with stock, he can fill in by cutting insulation, making brushes or doing other odd jobs. In a real small shop of two or three men one can devote part of his time to stock records. With the new visible-type card racks, the work can be done quickly.

One other bugbear of the perpetual card system is the matter of small items of material with low value, such as soldering paste, solder, paint, glue, etc., doled out in almost immeasurable quantities. These can be handled very easily on a budget basis. They are issued to the shop in standard quantities and so taken care of on the cards, being charged to "Budget Material." The foreman then makes an estimate of budget material used on each job and charges it to the job in a lump sum —thus eliminating many entries that otherwise would be needed.

Such a card system is invaluable to the repair shop as it prevents running out of important items, keeps stock investment to a minimum, boosts turnover, makes it possible to buy more intelligently and forms an up-to-the-minute cost record of material used.

Service is a word that has been very much abused in business, but if there ever was a business where service was spelled in capitals and meant everything that has ever been connected with the word that business is the motor-repair business. When an important motor breaks down, its owner wants it back in operation with the least possible delay. "Alibis" about lack of men or material do not interest him. If the machine is important enough, he is willing to spend money for overtime work or for making up special parts that could be bought much cheaper from distant factories; in fact, everything that will save time is acceptable without a great deal of regard to cost. The shop that maintains the men and equipment and material stocks to take care of this class of customer promptly and efficiently does not have to worry about price-cutting competition. A great reputation for real service is one of the best assets a repair shop can have.

Such a shop may lose a customer through intensive solicitation or price-cutting on the part of its competitor, but the customer will soon be back if he does not get real service.

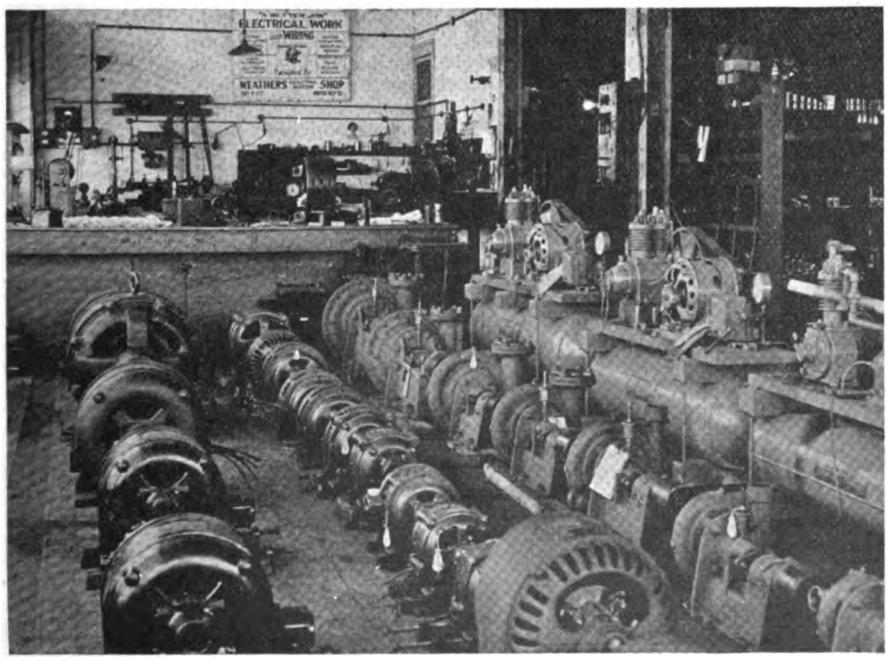
This service must not only be top notch as to speed but also as to quality of material and workmanship. The material should be only the best of its respective kind. It is poor economy to try and save a few pennies per yard or pound of material when such saving may cause a breakdown on a job where the labor and overhead involved is many times the total cost of material used. Likewise with labor, the high-grade workman is the best investment in the long run. Cheap, inefficient workmen will waste material and make dissatisfied customers through defective workmanship.

Since repair work is an expensive proposition at its best in comparison with the original cost of apparatus, everything possible should be done to reduce costs. The liberal use of labor-saving machinery is one of the best means to offset the high labor charge and at the same time make better service possible. Wherever possible the original factory methods should be duplicated. A trip each year to East Pittsburgh, Milwaukee, Schenectady or other motor-manufacturing centers is very important and will help you do better work.

To sum it all up, good service in a motor-repair shop requires an efficient combination of high-grade men, materials, equipment and record forms.

If there ever was a business where service was spelled in capitals, it is the motor-repair business.

The shop that maintains the men, equipment, and material stocks to take care of this work promptly and efficiently does not have to worry about price-cutting competition. This service consists not only in repairing motors quickly, but in making loans or renting spare equipment, as well as being able to supply new or second-hand equipment.



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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E. GOODING A. J. WHITCOMB

Chicago, January, 1925

You Can Do Whatever You Think You Can

THE first of every new year presents an opportunity for cleaning the slate of old-year deficiencies and failures and the making of new resolutions. It is good that this is so, for by our experiences, good or bad, do we profit when serious consideration is given to those things that tend toward personal advancement or larger business accomplishments.

Whatever may have been your lot in 1924, for the new year make your plans comprehensive in scope and definite in detail—aim your hopes high, and load yourself to the capacity of your ability. Remember that plans narrow in scope and small in possibilities stir up little enthusiasm, while an aspiration for big things that you believe possible, places you in the group of forward thinkers and doers. The world expects more of you year by year and you are better fitted after each twelve-month period to do the things you might not have aspired to during the years that have passed.

Edgar A. Guest furnishes a lot of inspiration in the following lines:

Success! It's found in the soul of you
And not in the realm of luck.
The world will furnish the work to do
And you must furnish the pluck.
You can do whatever you think you can;
It's all in the way you view it,
It's all in the start you make, young man,
You must feel that you're going to do it.

Let Mistakes Teach Their Own Lesson

RECENTLY the coil winder in a repair shop made an error which necessitated junking a large number of armature coils. He frankly admitted that it was a careless mistake and expressed his regret over its occurrence. Nevertheless, the foreman promptly discharged him, although his previous record was good and he was known as a careful, conscientious workman. When he applied for a position at another shop he told the whole story of his dismissal, and was hired at once.

Whether the first foreman acted too hastily or was justified in the course he took, may be open to argument. However, the man who hired this winder, knowing all of the facts in the case, explained why he did so as follows: "This man has had considerable experience and is a good winder, but he is a better man now than he was before because he has *learned his lesson.* Unless I am badly mistaken he is going to be much more careful from now on; he is going to be sure that he is right—and that is the kind of a man I like to have."

Leaving out of consideration the habitually careless workman, who is expensive at any price, the question of what to do with the man who makes one or two bad mistakes is not easy to answer. The natural impulse is to discharge him, which is, of course, an easy matter; to get a better man in his place may not be so easy. Moreover, there is no assurance that the new man will not make mistakes which are just as bad or worse, unless he has sometime been discharged or otherwise disciplined for an error in judgment, or carelessness, and thereby learned *his* lesson.

Although circumstances may clearly indicate the best course to pursue in a given case, it is probably safe to assume that when a conscientious workman makes a costly but unavoidable mistake he is just as sorry about it as anyone else is, and resolves that if carefulness will prevent it he is not going to make that mistake again. Such a frame of mind is worth a whole lot of discipline and is one of the best possible forms of insurance against careless slips of mind or hand.

Where Will Your Future Executives Come From?

ONE of the most common causes of disagreements is ignorance of, or failure to appreciate, the other fellow's viewpoint. If we do not understand what he is trying to do, or what his motives are, it is easy to infer that he is indifferent, unfair or that he uses poor judgment. In this connection the following letter received by the Editors of INDUSTRIAL ENGINEER is of unusual interest:

I was pleased with Mr. Chester A. Williams's very fine article on page 551 of the November issue, but feel obliged to take exception to his final paragraph, in which he seems to say that good men are hard to find.

There are hundreds of splendid chaps everywhere, possessing engineering or technical training—many of them, like myself, with considerable all 'round practical experience—who are ambitious and very anxious to completely finish their trade practically and theoretically, even at some expense to themselves. These men are willing to go anywhere for the chance of getting a decent show at a substantial future. They are willing to give maximum hours and their best efforts at any wage during such necessary apprenticeship, but are often unable to secure openings in worth-while plants that will give them this opportunity of definitely finishing their trade and quickly becoming in some form, a tangible, profitable asset to industry.

We are not afraid of work, much less of dirtying our hands, but the fellow determined on getting his electrical trade first, before expecting the big money, is facing a long, hard, discouraging proposition due to the almost complete absence of any degree of co-operation in his welfare among the various industrial plants and contractors, especially in the East.

American industry has a plentiful supply of real good, live material in its new recruits; men who are capable of development into any future responsibility—but they must receive some encouragement which, I am sure, would result in greatly minimizing any plant's labor turnover.

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In these statements there is much food for thought on the part of plant owners and executives. Granting that the interests of employers and workmen do not always exactly coincide, each wants something that only the other can give. The employer wants skilled service, a sense of craftsmanship and the kind of loyalty and faithfulness that can be depended upon to do the best possible job under any circumstances. The workman wants pay commensurate with his skill and the value of his services, a reasonably permanent job and a fair chance to win advancement in responsibility and rewards.

If a workman feels, rightly or wrongly, that he is not getting these things, he will inevitably seek a new position. If an industrial plant gets the name of being unfair in one way or another to its employees, it will have difficulty in securing and holding the ambitious young fellows who will be in responsible positions ten or twenty years from now.

Perhaps the statements in the above letter do not apply to you, but it will do no harm to check up your practices and policies in the light of this letter and see if your future master mechanic, chief electrician or other executive now in the ranks but as yet unknown is being properly trained and encouraged to work for the position which you may some day be glad to offer him.

The Peg on Which Good Salaries Hang

IN THE Buick body factory at Flint, Michigan, one of the largest of its kind, the man responsible for getting production through the curtain, light and repair department is Foreman Clyde Wing. This statement may not mean much until you know that Mr. Wing is just twenty-one years old and one of the best-liked leaders in the Buick works. He started in factory work five years ago as an office boy and simply worked himself out of that job by not only being the busiest office boy around the plant but the most observing one. It was not long before he was transferred to a division of the production department, where his remarkable ability to grasp details and effectively follow up the necessary routine on production procedure brought him a position, in the short period of five years, that has taken many others a life-time to acquire.

We cite the case of Clyde Wing to illustrate the fact that in factory work today the call is for men who possess initiative, who are self-starters, in brief, and do not require supervision any more than the president of the corporation requires supervision. When men ambitious for more salary and promotion from routine work can show that they have the qualifications to see beyond the horizon of the average fellow worker and at the same time demonstrate this by actual results on any job to which they may be assigned, then the promotion of these men will be just as quick and certain as that of Clyde Wing.

Imagination of inherent ability is never a substitute for accomplishment. All the Clyde Wings have stood the test and won on their merits, not on their conversation about themselves. In these days of high-speed, specialized production, it's not what you think but what you know about a thing that interests the boss—and that's the peg on which good salaries hang.

Don't Risk Your Reputation for a Few Cents

IN HIS article on operating motor repair shops, which begins on page 27 of this issue, Mr. Svendson makes the following pertinent statements: "The material should be only the best of its respective kind. It is poor economy to try and save a few pennies per yard or pound of material when such saving may cause a breakdown on a job where the labor and overhead involved is many times the total cost of material used. Likewise with labor, the high-grade workman is the best investment in the long run."

Economy in buying labor and material and in managing a repair shop is a laudable virtue and worthy to be practiced so long as it results in an actual, not apparent, saving in money, time and effort. Nevertheless, there is a point beyond which economy is not profitable. That is the point where quantity or quality of materials, labor and workmanship are cut below the minimum requirements for a good, serviceable job. That is the kind of economy that wastes a dollar in trying to save a few cents. A saving of a dollar or two on a gallon of varnish will make only a trifling difference in the cost per coil, while the difference in the quality of the varnish may make all of the difference between a job that stands up in service and one that does not.

The same thing is true of insulating materials, labor and all of the elements that enter into any repair job. Cheap materials and cheap labor may be worth all you pay for them—but if you do not pay much for them, as compared with the corresponding prices for standard materials and high-grade workmen, you can not expect much out of them.

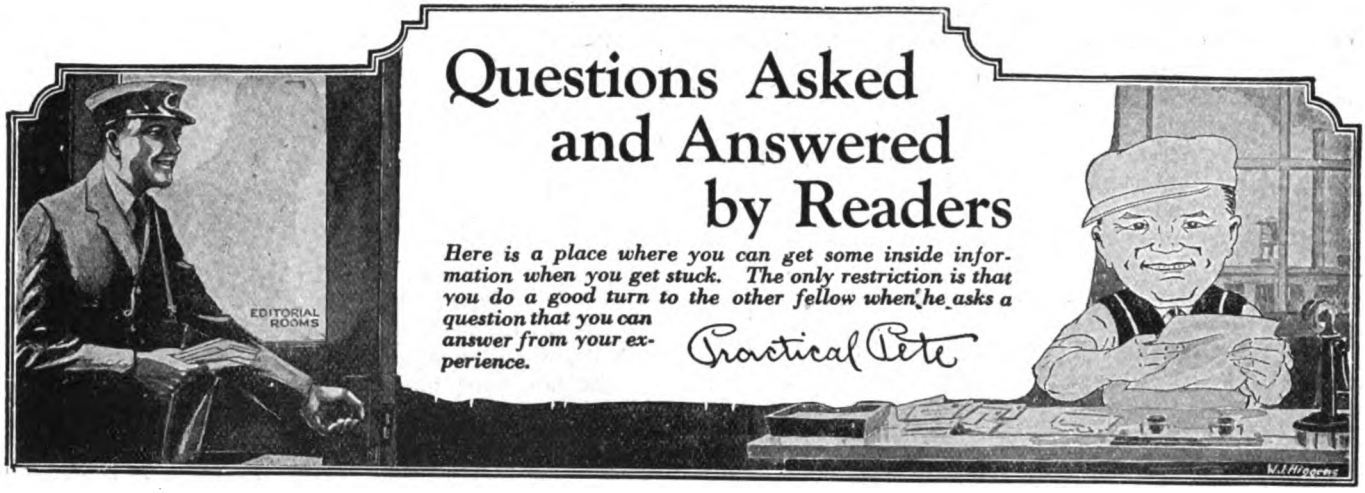
If your personal reputation, or the reputation of your department, is worth anything to you, do not risk it for a few cents.

Following Precedent or Following the Leader

PERHAPS in no other industrial field has precedent been followed so blindly as in material handling. Man-power in the form of "common labor" has been relied upon to perform this service. Ordinarily it has been considered as "cheap" because it has been placed as a lump in the general heading "overhead." However, those concerns which have made a detailed cost analysis of this work have found that this labor is expensive.

In addition to this, immigration restrictions have reduced the number of men available for this work as those who come into this country can soon get better jobs. To some this may seem a calamity while to others it is merely a demand upon their genius for a method of doing this work mechanically. While many devices have already been invented and placed on the market to do the work of strong-arm labor, industry as a whole has been reluctant to forsake precedent and take advantage of them. Those companies which have applied this equipment have found that it not only results in the elimination of the troublesome problem of providing this labor but at a considerable reduction in cost. This is the time to disregard precedent more than ever and adopt material handling methods shown to be practical by those who are leaders.

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Who Can Answer These?

Locating Trouble in Power Circuits Run in Conduit—Can some reader tell me what is the usual method of testing for and locating short-circuits, grounds and so on in power circuits which are run in conduit, and from which branch circuits for motors and other equipment are taken off at intervals? I shall be very grateful for your suggestions and advice.
Pittsburgh, Pa. J. L. B.

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Throwing Large Squirrel-Cage Motors Across the Line—Will someone who has had experience with starting large squirrel-cage motors (50 hp. and larger) by throwing them directly across the line, please report their results? Has such practice injured the motors in any way? Has it resulted in any damage to the machinery driven? Has it interfered with the supply of current to other motors in the same plant?
Indianapolis, Ind. D. W. T.

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Testing D.C. Armatures With Voltmeter—(1) Will some reader please tell me where to place the lampbank leads on the commutator when testing direct-current armatures with a voltmeter? For example, in the case of a four-pole armature should I touch the leads to the commutator on the quarter or on the half? Where should the leads be placed on a six-pole armature; or an eight-pole armature? (2) When testing a four-pole armature I touched the lampbank leads to the commutator on the quarter and got a good reading on the meter until I came to the next quarter of the commutator. Then the deflection was in the opposite direction. When I reversed the meter leads there was no reading on two bars of the quarter. Continuing ahead I got a good reading until the next quarter was reached. What did that indicate?
New York, N. Y. H. B.

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Making Tight Joint Around Prism Lights in Cement Sidewalk—Will some reader of INDUSTRIAL ENGINEER please tell me how to make a durable, water-tight joint between the cement slab holding the square prism lights and the cement sidewalk, over our basement? The crack all around these slabs is from ¼ in. to ⅝ in. wide and 1½ in. deep to the flange that carries the weight of the slab. The temperature varies from about 15 deg. F. in winter to 125 deg. F. or more in summer.
Dallas, Tex. F. A.

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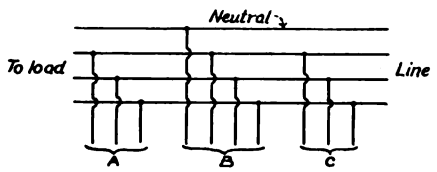
How to Determine Amount of Plugging Resistance to Use—I would like to know the right way to figure the amount of resistance used for starting series motors that are plugged, such as on blooming-mill, roll-table motors, crane-trolley motors, or any motor that is subjected to plugging service. I would also like to know how to figure the resistance used in the secondary circuit of slip-ring motors driving fans.
Mingo Junction, Ohio. E. E. S.

Connecting Watt-hour Meter to Three-Wire Circuit—Will some reader please give me a diagram and explanation of how to connect a watt-hour meter to an Edison three-wire circuit? Is a special type of meter required? Why?
Bellaire, Ohio. J. R. B.

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Connecting Westinghouse Type C Watt-hour Meter to 3-Phase, 4-Wire Circuit—Will some reader please tell me how to connect a Westinghouse, type C, switchboard, induction watt-hour meter to a three-phase, four-wire system having 2,300 volts between the neutral and each phase wire and 4,000 volts between phases? In the diagram, *A* and *C* are three-wire circuits supplying current at 4,000 volts, three phase, while *B* is a three-phase, four-wire circuit. One meter must measure the total power consumed.

The current transformers must be delta connected and three 2,300-volt voltage transformers must be used, as there are no 4,000-volt transformers on hand. I should also like to know whether it makes any difference if two or three current transformers are used on feeders *A* and *C*.
Guayama, Porto Rico. R. S.



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Standardizing Weight of Belting—I understand that some plants have standardized the weight of belting which they use; that is all belts are single-, double-, or triple-ply, the width of the individual belts being properly proportioned to the power that is to be transmitted. I should judge that this plan would simplify stock-keeping and reduce the amount of belting necessary to be carried on hand. However, I should like to know if any of the readers of INDUSTRIAL ENGINEER have done anything of this sort and what the advantages of such a procedure are.
Chicago, Ill. H. D. B.

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Winding Data for Peerless Fan Motor—I have a single-phase, 60-cycle, 110-volt fan motor, manufactured by the Peerless Electric Co., Warren, Ohio. It has twenty-four slots, solid rotor, no starting switch and appears to have a three-phase winding. I shall apprecite it if some reader can give me a diagram of the connections, as well as information on the choke coil in the base of the fan. The motor has evidently been rewound; sixteen coils have sixty turns of No. 25 wire and the remaining eight coils have seventy turns of No. 25 s.c.e. wire. The coil pitch is 1-and-6. The choke coil has also been rebuilt, but the motor does not run fast enough to disturb the air and also has a ground in it. I believe the motor was not rewound correctly as to size of wire and number of turns.
Mishawaka, Ind. L. C.

Answers Received To Questions Asked

Lining Up Sprockets for Chain Drives—Can some reader tell me the best and simplest method of lining up sprockets, or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.
Decatur, Ill. J. L. B.

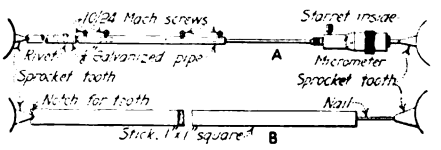
With reference to J. L. B.'s question in the November issue, I presume that he has reference to chain belts of the type manufactured by the Link-Belt Company, the Morse Chain Co. and the American High Speed Chain Co. I have handled such drives for the past six years and use the following methods, which have always proven entirely satisfactory:

Referring to the sketch, take two pieces of ⅛-in. galvanized pipe of the proper length to suit the requirements, which depend entirely upon the centers of the shafts. About 42 in. to 48 in. is the maximum that I have had to deal with, with a 2½-to-1 or 3-to-1 ratio. Drill two holes through the end of one pipe, the first hole being about ¼ in. from the end; the other hole should be about 1 in. further back. I use a No. 21 drill. Tap out the holes for 10/24 or 10/32 machine screws. Drill both ends of the first piece of pipe in this manner:

The second piece of pipe requires no holes, but a round piece of iron stock should be driven tightly in one end for fitting into the second section. Drill a small hole through the pipe and rod and put in a small iron rivet, peening it over on the under side.

Round out the opposite end of this piece sufficiently to fit over the sprocket tooth. Then fit a Starrett inside micrometer into the other end of the first piece of pipe. At (A) in the sketch is shown a complete assembly of the gage ready for use. This is really an adjustable pin gage.

Place the two sprockets face to face



Method of aligning chain drive sprockets, A, by means of improvised pin gage and, B, by a wooden stick.

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in approximately the position in which they are to run; then center them by squaring the sides with a steel straightedge or its equivalent. Gage in between the teeth, as shown in the sketch, until the outside edges of the two teeth selected are within 0.003 in. of being parallel. If the centers are then correct, the sprockets are lined up about as closely as it is possible to get them for all practical purposes. Sprockets should be carefully examined before placing on the shaft to detect blowholes and eliminate any high spots that might exist. When machining, blowholes in the inside of the shaft hole cause the tool to jump and the result is high spots. If this condition is not remedied a "wobble" will result.

In case an inside micrometer cannot be obtained, a piece of yellow pine 1 in. square can be used. Cut the timber to the proper length, notch it on one end and drive a small nail into the other, filing off the head to a round point. Adjustment can be made by driving in or withdrawing the nail with a pair of pliers. If this outfit is carefully used the results obtained will be about as good as with the micrometer.

A chain belt should never be too loose; the sag in operation should never be over 1 in. or 1½ in. on the slack side; otherwise in case of a reversible drive or dynamic braking a slap will result.

For roller sprockets a good straightedge or fine chalk line applied to the sides of the sprockets to bring them center to center and in alignment, should be sufficient. I have used the above tools for a good many years and have yet to hear a complaint about a drive so lined up. The tools employed can be obtained in any good industrial plant machine shop. Any mechanic can make for himself the two pieces of pipe used for an extension, and when once made they are always ready for use. The joint in the pipes is for dismantling so that they can be placed in the tool case; otherwise a joint is not necessary unless the shaft centers are rather short.

General Engineer, P. S. PENDER.
Metropolitan Engineering Co.,
Granite City, Ill.

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How Does Change in Speed of Motor Affect Horsepower?—I shall appreciate it if some reader of INDUSTRIAL ENGINEER can answer the following question: We have a 3-hp., 3,600-r.p.m. motor which we are changing to operate at 1,800 r.p.m. I should like to know what the approximate horsepower of the motor will be after this change, if we use the same number of turns of the same size wire in the stator.

Enid, Okla. C. E. S.

In answer to the question by C. E. S., in a recent issue, the horsepower will be approximately half of what it was originally. Likewise, the applied voltage must be reduced to approximately half of its original value, because a change in speed, which varies inversely as the number of poles must be accompanied by a change in voltage. It must be remembered, also, that a change in the pitch factor must be accompanied by a change in the applied voltage if the operating characteristics of the motor are to remain normal. The new pitch factor should not be smaller than 0.5 nor greater than 1.5. There are practical limits beyond which this form of reconnection cannot properly be carried. The connection which you suggest would not normally operate at the same voltage nor would the horsepower developed be the same. If the speed of a motor is reduced one-half by a change in the number of poles, in order to operate it at the proper voltage, special taps from the transformer would be required. Otherwise, some other changes would have to be made in the motor winding at the same time that the number of poles were changed. If C. E. S. will tell me how many coils are in this motor and the original connection, I will be glad to tell him how to group the coils for the new speed.

Ass't Superintendent, H. J. ACHEE.
City Water and Light Dep't.,
Woodward, Okla.

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Operating 25-Cycle Transformers on a 60-Cycle Circuit—We are operating a 2,300-volt, sixty-cycle, three-phase system and in a short time will be called upon to furnish some additional lighting and power service. Our present transformers are not sufficiently large to handle this additional load and we do not wish to purchase new ones as the load will be on for only a few days. We can rent 2,300-volt, twenty-five-cycle transformers and I should like to know if these will work satisfactorily on the sixty-cycle current. Will the secondary voltage be the same as on twenty-five cycles? If not how much will it be below normal?

Carthage, Mo. A. P. K.

In the November issue, A. P. K. asks if 25-cycle, 2,300-volt transformers can be expected to operate satisfactorily on a 60-cycle circuit. The main difference between 25-cycle and 60-cycle transformers is in the iron laminations. Because the reversals are slower with 25-cycle current than with 60-cycle, the iron has more chance to get saturated. Therefore, 25-cycle transformers are designed with thicker iron laminations and more iron, in order to take care of the increased heating. Using 25-cycle transformers on 60 cycles only means that the iron will heat much less because the higher current frequency does not have time to build up the magnetism. The core loss will, therefore, be less than if the transformers were operated on their normal frequency. The copper loss should remain the same. The regulation at unity power factor should be the same. The secondary voltage should be the same as though the transformers were operated on their normal frequency.

Using these 25-cycle transformers, as suggested, should be satisfactory as an emergency measure, but it would not pay to buy 25-cycle transformers when 60-cycle units can be obtained, because of the much higher price of the 25-cycle equipment. R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

Referring to A. P. K's. question in the November issue, a standard transformer designed for a definite frequency may be operated at frequencies which are considerably higher or lower than normal. If the transformer is designed so that at normal frequency and full load the copper and iron losses are equal and the efficiency maximum, at lower frequencies the iron loss will be larger than the copper loss and at higher frequencies the copper loss will be the greater.

A transformer designed for a given output and frequency can be operated at the same output on a higher frequency with somewhat reduced heating, but if operated on a lower frequency it will run somewhat hotter and the efficiency will be slightly lower. Modern transformers, however, usually have sufficient capacity to be operated on half-frequency without injury. When operating a 25-cycle transformer on a 60-cycle circuit, a power transformer would give better results than a lighting transformer, because the core loss and the copper loss are about equal in the former, whereas in the lighting transformer the copper loss will be greater than the core loss. The secondary voltage will be the same as when the transformer is operated on 25 cycles.

Thompsontown, Pa. C. D. SHAFFER.

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Replying to the question by A. P. K. in the November issue, transformers designed for operation on a 25-cycle circuit will operate satisfactorily on a 60-cycle circuit; they will, in fact, operate better at 60 cycles than at 25 cycles. This is due to the fact that for the same kva. capacity a 25-cycle transformer must have a core of greater cross section. The reason may be understood by referring to the standard formula, $E=4.44\times f\times \phi\times T\times 10^{-8}$, where (E) is the voltage, (f) the frequency, (ϕ) the total flux, and (T) the number of turns.

This formula may be written, $E=K\times f\times \phi\times T$, where $(K)=4.44\times 10^{-8}$.

For a certain voltage the product of (f) and (ϕ) must be constant, since the number of turns is fixed; therefore, if (f) is changed from 25 to 60 cycles (ϕ) must become less or decrease in proportion to the increase in frequency. This decrease in the flux will more than offset the increased losses, due to increase of frequency, in hysteresis and eddy currents.

The secondary voltage will be the same as at 25 cycles.

As a general statement it should, however, be borne in mind that a transformer designed especially for operation on a 60-cycle circuit would overheat and probably burn out if operated on a 25-cycle circuit.

C. OTTO VAN DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

Replying to the question by A. P. K. in the November issue, the following statements may be made: (1) The iron losses will decrease. (2) The reactance of the transformers will increase in the ratio 60/25. (3) The impedance will be increased. (4) If the load is carried at 100 per cent power factor the secondary voltage will be the same, or normal, regardless of whether the current supply is 60 cycles or 25 cycle. However, this is rarely the case and as the power factor drops the voltage drop will be much above normal; that is to say, it will be greater than it would be under the same conditions of load and power factor at 25 cycles. The voltage drop will depend on the design of the transformer and in the absence of the design data it is not possible to say what the resultant secondary voltage will be. (5) If the 25-cycle transformers must be operated in parallel with 60-cycle transformers their capacity will be decreased because the impedance is increased. When several transformers working in parallel all have the same impedance the load will be distributed among the different trans-

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formers in proportion to their capacities. However, if the impedances are not the same the transformer having the higher impedance will take the smaller load.

Liege, Belgium. P. VAN HERK.

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With reference to A. P. K.'s question in the November issue, it will be satisfactory to operate 25-cycle transformers on a 60-cycle circuit. The secondary voltage will be the same as on 25 cycles.

The iron loss will be about one-half of the value it would have on 25 cycles, while the copper loss will be approximately the same. This means that the transformers will have a greater capacity on 60 cycles than on 25 cycles, the amount depending upon the ratio of iron loss to copper loss in these particular transformers. However, increased loading is probably not important in this case.

East Cleveland, Ohio. L. T. JOHNSON.

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Replying to the question by A. P. K. in the November issue, 25-cycle transformers can be used on a 60-cycle circuit under certain conditions. For example, they will carry about one-half their rated load very well, but they will run warmer than normal and both iron and copper losses will be greater than would be the case if the transformers were designed for 60-cycle operation. The increased iron losses would be caused by an increase in eddy currents as the laminations of 25-cycle transformers are usually thicker than those in 60-cycle transformers. Eddy currents are proportional to the thickness of the lamination and to the frequency.

The copper losses will be greater for a given current than in 60-cycle transformers as there is more wire in 25-cycle transformers, and the latter will thus operate at a lower efficiency at 60 cycles. The secondary voltage will, under light load conditions, be normal, while the regulation will be less close, depending on the load.

Muncie, Ind. GEORGE CROPPER.

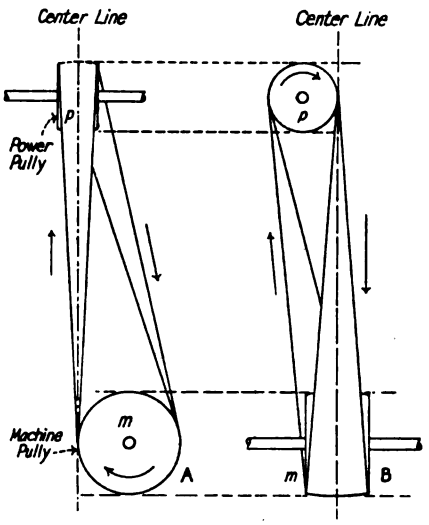
* * * *

How Should This Machine Be Placed?—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.

Philadelphia, Pa. A. T. S.

In answer to A. T. S.'s question in a recent issue, almost any machine can be placed at an angle of 90 deg. or less away from the power lineshaft, providing that the belt is properly lined up to both pulleys. In the first place, note the direction of the power pulley (P), in the illustration (A), then drop a plumb line off its periphery toward which the belt is traveling.

The machine pulley (M) must then, if turned at 90 deg., have its periphery just touch the plumb line. It will be noted that as the belt is traveling from the machine pulley (M) up toward the power pulley (P) it approaches the latter along a perfect center line, which is correct.



Method of lining up lineshaft and machine pulleys when shafts are at right angles.

Now, the slack side of the belt, going downward from the power pulley and approaching the machine pulley, must travel along a line at right angles to the shaft of the machine pulley, see illustration (B), so as to ride upon the latter on the face center.

This adjustment may be rather difficult if the machine cannot be shifted into line, but easy if it can be. However, a plumb line or straight edge extended upward from the face center of the machine pulley, should just touch the periphery of the power pulley, as in (B).

If the direction of the lineshaft is reversed from this diagram, the pulleys must be lined up in other positions, as that side of the belt approaching each pulley must be on its center line, and not approach it from an angle. However, the belt can leave each pulley at an angle, with no bad effects.

If pulleys and belt are properly lined up to a machine at any angle up to 90 deg. from the power shaft, no guides will be required to keep the belt on the center of the crowns, for it will ride there perfectly. If it does not, the lining up was faulty.

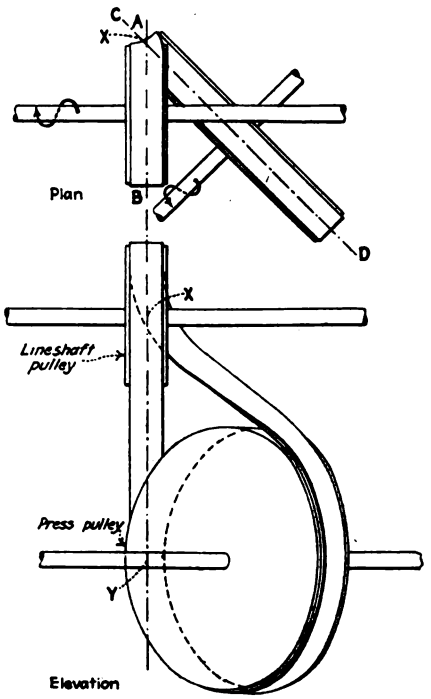
Any ratio of pulley diameters may be used.

New Britain, Conn. H. S. RICH.

* * * *

Referring to the question by A. T. S., in a late issue, the condition which he describes is simply one variety of the quarter-turn belt drive, and while such a drive is not common, it could hardly be called unusual. The chief reason it is not more common is that the driven pulley, if its shaft is to be level, must be located below the lineshaft pulley as shown in the accompanying diagram.

If the press is run the other way, it must be shifted to the opposite side of the lineshaft. The only precaution essential to observe in a drive of this sort, is that the point at which the belt leaves one pulley of the drive must be in the plane of the other pulley of the drive. Thus calling the plane of the lineshaft pulley (AB), in the diagram, and the plane of the press pulley (CD), it will be seen that the point (X) where the belt leaves the lineshaft pulley is in the plane (CD) of the press pulley and that the point (Y) where the belt leaves the press pulley is the plane (AB), and that these points are directly over one another.



When the lineshaft and driven shaft are at an angle to each other, the point at which the belt leaves one pulley of the drive must be in the plane of the other pulley.

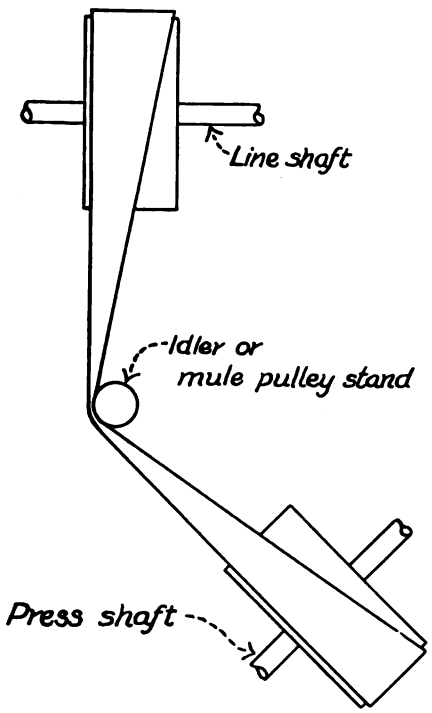
Drives of this sort work better where belt centers are long compared with the diameters of the pulleys and with the pulleys well crowned, but that there is more or less latitude in setting can be seen from a case in one shop where I worked that had a row of drill presses located directly under the lineshaft and driven by quarter-turn, shifting belts.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

* * * *

In reply to A. T. S., whose question appeared in a recent issue, on special drives or when turning corners it is not an uncommon thing to use a belt drive similar to the one which he described. This arrangement is more common with rope drives, however, and in that case is much easier to handle, because the rope does not resist twisting as much as belting does. This type of drive is used only in special cases and is more troublesome than the ordinary type; also it tends to shorten the life of the belt. I believe that A. T. S. will understand the principle from the diagram. The exact location of the idler or mule stand can be determined by experiment. If he is interested in the subject to any extent, I would refer him to Marks Mechanical Engineers' Handbook which gives good "dope" on this subject. It is, as well, a good ref-

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Relative location of lineshaft, driven machine and double idlers or mule stand for angular drive.

erence book on all kinds of mechanical problems.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Why Do These Commutators Turn Black?—I am experiencing a great deal of trouble from blackening of the commutators on two G. E. belt-driven, type ML, compound-wound, 125-volt, 950-r.p.m., 13 kw., d.c. generators which are used as exciters. After smoothing with sand paper, it is only a matter of a few hours until the commutators are in the same condition again. I have tried turning the commutators in a lathe and undercutting the mica, polishing, sanding, using Ideal commutator stone and tightening the commutator. Also, I have used four different grades of brushes and am now using Speer E-25 brushes. There is no sparking at all under varying loads. The setting of the brush holders was changed from leading to trailing and I found that they worked best leading. I have tried the brushes at different angles and found that the best results were obtained when they were set at about 80 deg.

We wipe off the commutators once each day with a dry piece of canvas. I have checked the brushes for the neutral position. The tension on the brushes is 1½ lb. per sq. in. The temperature seems normal except when the commutators get very black as they will do if they go about a week without sanding. These exciters are only two years old and have been in actual service about one year each. I have had this trouble from the start.

I shall appreciate it very much if some reader of INDUSTRIAL ENGINEER can tell me what the trouble is and how I may cure it.

Woodward, Okla. H. J. A.

In answer to H. J. A., in a recent issue, it seems that you have tested for most of the usual sources of trouble without much success. Inasmuch as you are sure that the commutator is tight and remains tight when it warms up, I would advise you to see if the armature is lap or wave connected. If it is lap connected, I would consider putting in equalizers. For this purpose, divide the total number of commutator bars by the number of pairs of poles, plus one. Put in as many equalizers as there are pairs of poles and space them equally between the first equalizer, as any irregularity in the armature, field or air gap will cause sparking in a lap wound armature. I would also suggest that you make a bar to bar test with a millivoltmeter and lamp bank and see if all the bars read alike. There might be a partial open somewhere. A partial open on any bar will cause it to read higher than the rest. It would also cause sparking and blackening of the commutator in certain places.

Also check up the pole pieces to see if they are equally spaced. If they are not almost equally spaced commutation will, at times, take place when the coil is not in the neutral zone.

I think it would also be well worth while to go over the connections of the brush rigging to see if they are all clean and tight, so that more current will not be carried on one brush stud than on another.

Finally, make sure that there are no bulky splices or unnecessary bumps on the belt, as these will cause sparking.

I hope that these suggestions will be of some help to H. J. A.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

With reference to H. J. A.'s question in a late issue of INDUSTRIAL ENGINEER, the only possible cause that I can think of for this trouble is belt lacing or a similar source of vibration.

General Manager, W. C. KALB.
Corliss Carbon Company,
Bradford, Pa.

* * * *

In a recent issue H. J. A. mentions trouble from blackening of the commutators of two small generators.

There are several possible causes of this trouble. One of the most common causes is an overheated commutator, which may be due to overload or to sparking which, in turn, may be occasioned by incorrect brush tension or a variety of causes. Sometimes it will be found that too much lubricant has been used on the commutator.

An overheated commutator may not be very noticeable at first, but after running for some time the commutator may become heated sufficiently to decompose the carbon brushes, covering the commutator with a black film which increases the resistance between the commutator and the brushes and thus increases the heating. If the brushes get very hot a brush of higher conductivity should be used, allowing a higher current density per square inch.

I believe that H. J. A. has the brush tension set too low. This would cause sparking that might not at first be plainly visible to the eye, but enough to cause the brushes and commutator to become heated in time. The pressure should be from 1¾ to 2¼ lb. per sq. in.; a safe average would be 2 lb. per sq. in.

As several grades of brushes have been tried without improving conditions it may be that a larger brush is necessary; a machine of this size should carry 118 amp. at 110 volts and should have at least 4 sq. in. of brush surface.

Carbon-graphite brushes give very good results as the graphite increases the conductivity and reduces friction. Sometimes the operating qualities of brushes may be improved by saturating them with some lubricating compound, although this is something that must be very carefully done and then only when the conditions plainly indicate it.

New York, N. Y. DONALD L. HOARE.

* * * *

Answering H. J. A.'s inquiry in a recent issue, this blackening is generally caused by disintegration of the brush material, due to some abnormal condition, usually excessive current density. It is a simple matter to calculate the nominal current density in a brush, but the figure thus obtained may bear very little relation to the actual density. The distribution of load between spindles of a machine is not always uniform, nor is the distribution of load between the brushes on one spindle. Finally, the current density on one side of the brush may be very much higher than the current density on the other side. Thus the actual density may be many times the nominal, and the brush may be loaded up far beyond its capacity, until the bond near the contact surface is destroyed in consequence of the excessive temperature and disintegration commences. Sometimes glowing or cratering of the brush is observed under these conditions. Sparking is not necessarily much in evidence. The cure for this is to improve the running conditions as much as possible, and to mount a more refractory grade of brush, a slightly abrasive electrographitic quality usually being the most suitable.

Experience shows that when cratering occurs on a brush it is better to substitute a more refractory type of brush that will stand up to the conditions than to substitute a hard carbon with a high contact drop, in the hope of bringing the load within the capacity of the brush by reducing the circulating current in this way.

Projecting mica is a very fruitful cause of blackening. It lifts the brushes off the commutator, increasing the total I^2R loss and therefore the heating; it upsets the distribution of load, and thus causes excessive current density and local overheating. Finally, by acting as a milling cutter, it assists in the disintegration of the brush. Recessing the mica will often cure the blackening without any change of brushes, although it may be necessary to remove a considerable piece from the end of a brush if the material has already suffered from the ill treatment.

When burning of the commutator surface occurs (which is usually accompanied by visible sparking) this in itself tends to blacken the commutator. It also roughens the surface of the segments, which then abrade the brushes and thus accentuate the blackening. Again the cure generally is to use a slightly abrasive electro-graphitic brush, after improving the running conditions as much as possible and

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especially putting the commutator into thoroughly good condition before mounting the new grade.

Blackening of the commutator surface not infrequently occurs on machines driven by gas engines, due to the corrosive action of the gases. If the commutator is thoroughly scoured, electro-graphitic brushes as described will usually prevent a recurrence of the trouble.

An excessive amount of dust in the atmosphere, such as coal, cement, or flour dust, is very likely to cause blackening by preventing intimate contact between brushes and segments, thus producing high local current densities and sometimes sparking which, of course, in itself tends to burn the brush and destroy its bond.

Oil vapor has sometimes been found to create a similar condition. Highly-lubricating, natural graphite brushes have proved very successful in cases where dust has been responsible, evidently by maintaining intimate contact and preventing the dust from working underneath the brush. For conditions where an oily vapor is present a slightly abrasive electro-graphitic brush has been found to effect a cure.

Morganite Brush Co., New York, N. Y. H. C. MILLS.

* * * *

H. J. A. asks a difficult question in a recent issue of INDUSTRIAL ENGINEER. The answer may be poor design. In my experience the only exception to this has been inequality of air gap.

In one particular case we had a motor that blackened under the negative brushes. The air gap was smaller on the bottom than on the top. We inserted shims under the top pole pieces, making the air gap equal all around the machine and the trouble disappeared.

If this remedy does not have any effect the only thing left is to slot the commutator (undercut the mica). This will improve matters somewhat, but if the commutator still continues to blacken the manufacturer should be notified and requested to make the machine operate as it should, without blackening.

Boston, Mass. EDWARD A. GIBBS.

* * * *

Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.

Toledo, Ohio. F. H.

In answer to F. H.'s question in the September issue, most manufacturers prefer a star to a delta connection for the reason that the delta connection requires 1.73 times as many turns for the same operating voltage, and these turns are of a smaller-size wire. There are several objections to the use of a large number of turns per coil. For example, more space is occupied in the slots for insulation, leaving less space for the copper. The coils are much less rigid, from a mechanical standpoint, and require more binding and bracing at the ends. Smaller-size magnet wire also costs more money per pound and the same number of pounds will be required in either connection. Further, it takes longer to make up a coil with a larger number of turns than to make one of larger wire and fewer turns. While it is not the best practice to use four-parallel star windings where two-parallel delta would serve the purpose, probably for the single-circuit winding the star connection is the better choice.

Donnacona, P. Q., Can. LEE F. DANN.

* * * *

In answer to F. H.'s question in the September issue, a large number of motors are built for stock and the windings used are such that by changing Y and delta connections and the series and parallel arrangements, it is possible to secure windings which will be suitable for a number of standard voltages.

The Y connection is more widely used in motors since the neutral point may be grounded. Also the slot factor is higher for a Y connection than for a delta connection. This means that for a Y connection only 58 per cent of the insulation required for a delta connection is used, or the ratio of copper to slot insulation is less.

CHAS. F. CAMERON.

Rock Springs, Wyo.

* * * *

In reply to F. H. in the September issue, I would say that so far as the operation of the motor is concerned one form of connection has no advantages over the other. Even in the original design of the motor it is often simply a matter of the designer's choice, although the star connection is probably the more generally used, whenever possible.

A given winding connected in star is good for 73 per cent higher voltage than the same winding connected in delta. In other words, a delta-connected motor must have 1.73 times as many turns per coil as a star-connected motor for the same voltage. This is because the star connection gives 1.73 times as many "effective" turns in series across each phase. This is roughly evident from studying the ordinary symbols for star and delta connections.

The usefulness of the two forms of connection lies with the designer. They give him more combinations which he may "juggle" to meet various conditions. For instance, in a large, low-voltage motor it might work out in the design that for a star connection there would be 2.31 turns per coil. It is impossible to make a coil with a fractional number of turns, but for a delta-connected winding for the same motor the number of turns would be $2.31 \times 1.73 = 3.996$, or very nearly four turns per coil; so the designer would use four turns per coil and a delta connection. This is, of course, merely an example, but it gives the idea.

A full discussion of this subject could not be given here and I would refer F. H. to A. M. Dudley's book, "Connecting Induction Motors," particularly the chapter on reconnecting old motors for new conditions. This book can be obtained from the McGraw-Hill Book Co., and is worth many times its cost.

Walkerville, Ont., Can. R. B. TURNER.

Priming Coat for Plaster and Brickwork—Will some reader of INDUSTRIAL ENGINEER please tell me what kind of sizing or priming coat should be applied when brickwork and plaster walls are being painted for the first time? We wish to paint the walls and ceilings of both office and shop and I understand that some preliminary treatment is necessary before the finishing coats of paint are applied.

Cleveland, Ohio. L. McC.

Replying to L. McC. in the October issue, when painting brick and plaster walls for the first time it is customary to apply a priming coat, which may consist simply of glue and water, in about the proportion of ½ lb. of glue to 10 qts. of water. The glue should be dissolved in the water while hot, and allowed to cool before using.

A better and more easily applied priming coat consists of, 1 gal. linseed oil, 2 qt. cheap varnish, 1 qt. turpentine, ¼ pt. drier.

To this is added sufficient white lead to give it a little color, so that in applying one can easily tell how much surface has been covered.

If the final finish is to be gloss, at least two coats of flat will be necessary before applying the gloss.

Guilford, Me. DONALD MAXFIELD.

* * * *

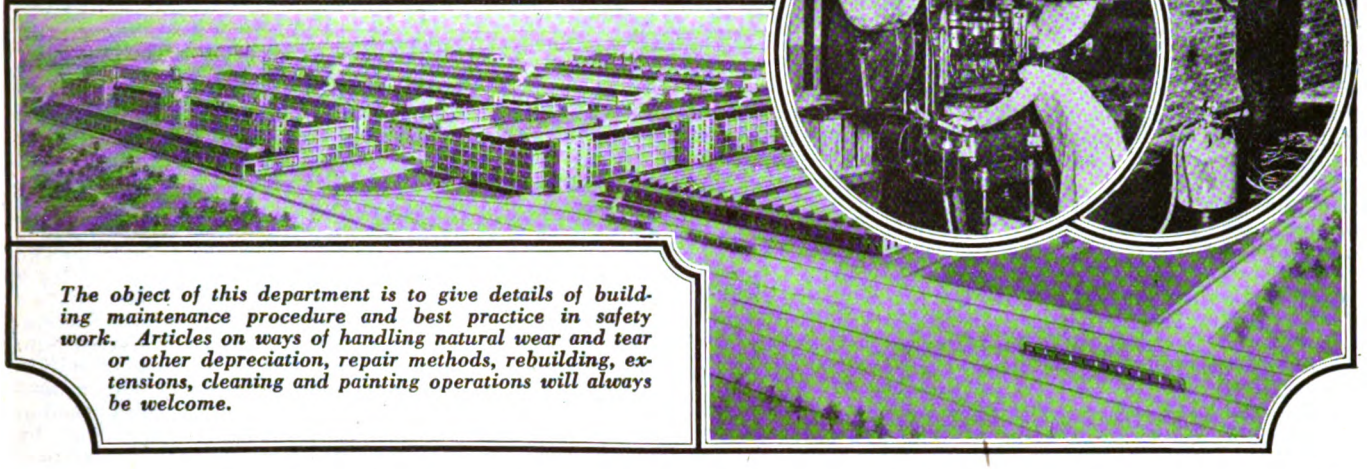
In reply to the query of L. McC. in the October issue, I would suggest the following treatment: First, remove all grease and oil from the brick and plaster by using benzine. If the plaster is new or damp, the surface should be well brushed with a solution of zinc sulphate (3 lb. to a gallon of water). Use an ordinary bristle brush and allow to dry 48 to 72 hr. Any good reliable make of undercoat should now be used, and it is well to add to the first coat an elastic primer in the proportion of 1 qt. of primer to 1 gal. of undercoat. For high-class work a second coat of undercoat (not reduced) should be applied, and finally the finish coat of flat, egg-shell or gloss, as may be desired.

For the brick walls it may not be necessary to use the zinc sulphate wash, although if the walls are newly laid or are damp it will be safer to do so. If the walls are well seasoned no sulphate will be required. The undercoat first coat reduced as for the plaster should be used, and the other coats as mentioned. All the various paint manufacturers put out brick and cement paints or coatings that will give satisfaction. The two points that must be taken care of are these: First, to neutralize the alkali in freshly laid brick or plaster, and, second, to fill up the pores in the material to prevent excessive absorption of the paint. The zinc sulphate serves to neutralize the strong alkali present in all plaster and cement work, when fresh, due to the existence of lime in a hydrated condition. If an oil paint is used directly upon this material the hydrated lime will unite with the oil of the paint, forming a soap and destroying the oil. Consequently the paint does not endure. When a solution of zinc sulphate is brushed over the surface a chemical action takes place, with the formation of two new compounds. The pores of the brick or plaster become filled with these two substances which are both inert chemically, or at least they do not affect the paint. In addition, they reduce to some extent the porosity of the material. The remainder of the porosity is filled up by adding the primer to the first undercoat as directed. Forty-eight hours should elapse between all coats.

Lawrence, Mass. A. J. CALHOUN.

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Building Maintenance and Plant Safety

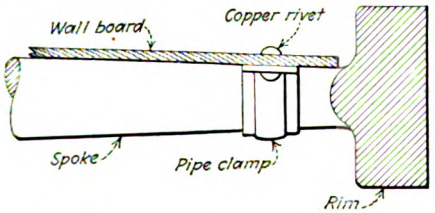


The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Substantial but Low-Cost Guard for Spoked Wheels

GUARDING of spoked wheels is coming in for attention because accident records show that flywheels, pulleys and gears need to be protected so that no one can thrust an arm or a leg through them inadvertently; herein lies the risk, and the accidents resulting have usually been of the most distressing sort. There is no good argument against guarding these wheels. Neatly guarded wheels look as well as open ones and also have the advantage, with disk guards, that the fan-like action is reduced.

One substantial type of guard for spoked wheels particularly of large diameter was adopted in one plant for a number of balance wheels about 3 ft. in diameter. How these were made and applied is shown in the accompanying sketch. Disks of a size to fit inside the rim were cut from wallboard of cheap grade. This material is about ¼ in. thick and is very tough. These disks were then fastened to the side of the wheels by using ordinary galvanized pipe or conduit straps or hangers. These straps or clamps were bent slightly to conform to the spoke shape and then were copper rivetted to the wallboard disk.



Method of guarding spokes or arms of a small flywheel.

A disk of wallboard is attached to the arms of the wheel by pipe straps and copper rivets. If preferred, disks may be attached to both sides. This not only gives added protection, but also reduces the fan action of the arms.

A better, safer guard would be hard to conceive. It passes any inspection and is good for any speed. If desired, the disk could be applied to both faces and the straps dispensed with.

DONALD A. HAMPSON.

Plant Superintendent,
Morgan and Wilcox Mfg. Co. ,
Middletown, N. Y.

Convenient Method of Filing Blueprints for Easy Reference

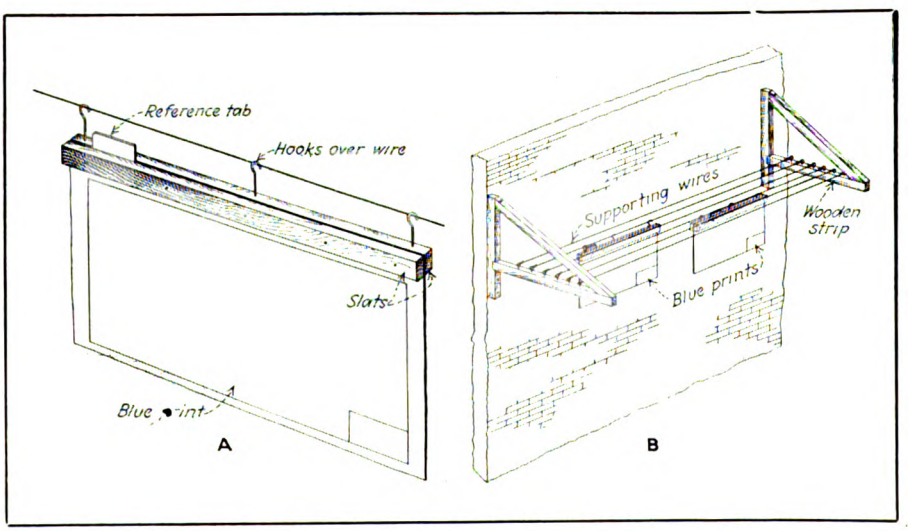
WHEN doing construction work it is often necessary to refer frequently to blueprints. However, these are hard to handle when rolled up and easily become torn. Under such circumstances I have found that the rack which is shown in the illustration affords a very convenient means of filing the blueprints in such a manner that they are protected from injury and yet can be located and referred to without difficulty.

The blueprints are nailed between two slats or thin strips of wood. Small hooks should be screwed into each end and in the middle of one of the slats. It is advisable to place a reference tab at the upper left hand of the blueprint to facilitate identification. The method of mounting the blueprints is shown in (A) of the illustration.

The rack is constructed as shown in (B). Two braces or supports are mounted on the wall, or in any convenient place. These supports should be spaced from four to six feet apart, depending on the size of the blueprints and a number of strong iron wires should be stretched tightly between them and fastened firmly.

The blueprints are then hung on the wires by means of the small hooks. It is advisable to hang all of them at one end of the rack: when a blueprint is to be examined, it can be slid over to the opposite end of the rack, away from the others.

Oakland, Calif. S. H. SAMUELS.



The blueprints are mounted between thin slats fitted with small hooks, A, and hung on wires stretched between two supports mounted on the wall, B.

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Some Troublesome Problems in an Industrial Works

EVERY engineer and mechanic of experience knows that trifling things sometimes stand between success and failure. For example, recently there was brought to my attention a case of poor design, or perhaps more correctly speaking, lack of design. A bakery using a large reel oven, into which steam is injected for a certain effect on the product, experienced trouble getting results. A boiler had been installed to furnish steam for heating and process work, one of the processes being baking. The management had been assured that steam-heating pressure, of 15 lb., would be sufficient to supply steam to the ovens.

Upon starting up the boiler pressure was entirely too low to supply the steam needs of the oven. Permission was obtained from the city boiler inspection department to increase the pressure and this, of course, required a licensed fireman. Also, a costly pressure-reducing valve was installed to protect the heating system. About 60 lb. pressure was found to be necessary to furnish satisfactory service. It is evident that no serious thought had been expended on the problem. A pressure of 15 lb. was not enough; that was quite clear. What could be more simple than increasing the pressure without looking into the cause of the trouble?

An investigation disclosed that about fifteen boiler-horsepower or about 8½ lb. of steam per min. was required by the oven during the time that steam was used. The piping from boiler to oven was the equivalent of 80 ft. of 1½-in. pipe, which served as a main and a header for the oven branches, which were made up of 20 ft. of 1-in., 7 ft. of ¾ in., and 13 ft. of ½ in. piping. Just what dictated the pipe sizes was not apparent. The velocity of the necessary steam passing through the ½-in. piping would have to be 40,000 ft. a minute. The same men who connected the steam-heating radiators with 1½-in. pipe, connected the two side-inlets of the oven with ½-in. pipe and the oven takes many times the steam required by a radiator. When the piping from the boiler is changed to 2 in. (which will also serve as a header for two ovens), and the oven branches to 1 in., a heating-pressure of 15 lb. will be sufficient.

A short time ago I was asked, "Why is it that so often the recommended auxiliary equipment proves entirely inadequate for the service?" The equipment discussed (or cussed) was a bucket elevator serving a grinding mill. Upon learning the capacity of the mill and the size of the elevator, simple calculations showed that the elevator should be large enough for the job; in fact, it was larger than I would install for the service. My friend yelled, "There you go now! I tell you the elevator won't handle it! We clean chokeups every hour!"

An inspection showed that the 30-in. head-sprocket was going at 45 r.p.m. This was much too fast and so I had the elevator-head removed. This showed every up-coming bucket heaping full and, when passing over the top of the sprocket, it would heave its contents upward so that the grain would then fall down the leg or casing, with little more than a handful entering the discharge spout. Changing the drive pulley so as to get a speed of 32 r.p.m. for the head-shaft corrected the difficulty. Over- or under-speed is a common cause of trouble with centrifugal-discharge elevators.

Compressed air is often a helpful convenience and could be used more if it were but thought of in emergencies. We are all prone to think of mechanism when a material-handling, or machine driving problem arises. Reciprocating steam-pumps can be operated satisfactorily, although not economically, with compressed-air.

A rotary dryer was fitted with a spout which, because of its steep pitch, was thought capable of readily chuting the material into the dryer. As the material was fine and moist it gave trouble from the start by choking the spout. A man provided with a pole was put to work prodding the material down the spout pending the installation of a screw-conveyor feeder. About this time my attention was called to the difficulty. Finding a compressed-air line close by, we carried a ½-in. pipe into the feed spout. A cock with a counterweighted lever was rigged up so that a pin on the end of the dryer opened the cock and the intermittent air blast at each revolution of the dryer effectively cleared the spout.

A bin at this plant gave considerable trouble by the choking of the discharge opening which made it necessary for a man to hammer the hopper with a sledge to start the material flowing. A ½-in. air pipe was projected into the hopper, and with a valve within reach from the floor the "hang-ups" were brought down by a quick opening of the valve. It was found that by keeping the valve "cracked," and permitting a small amount of air to flow into the material constantly, it was aerated and flowed freely. In using compressed-air for this last purpose it should be borne in mind that the air sometimes carries considerable water which, with some materials (cement, for instance) might cause damage.

And so on, indefinitely. Looking back over years of experience, it seems that most of the troubles encountered have been like those described. The remedy is simple. One big reason why it is not applied earlier is that those associated with it too often look more at the trouble than at the possible cause and the common-place remedies which may be applied.

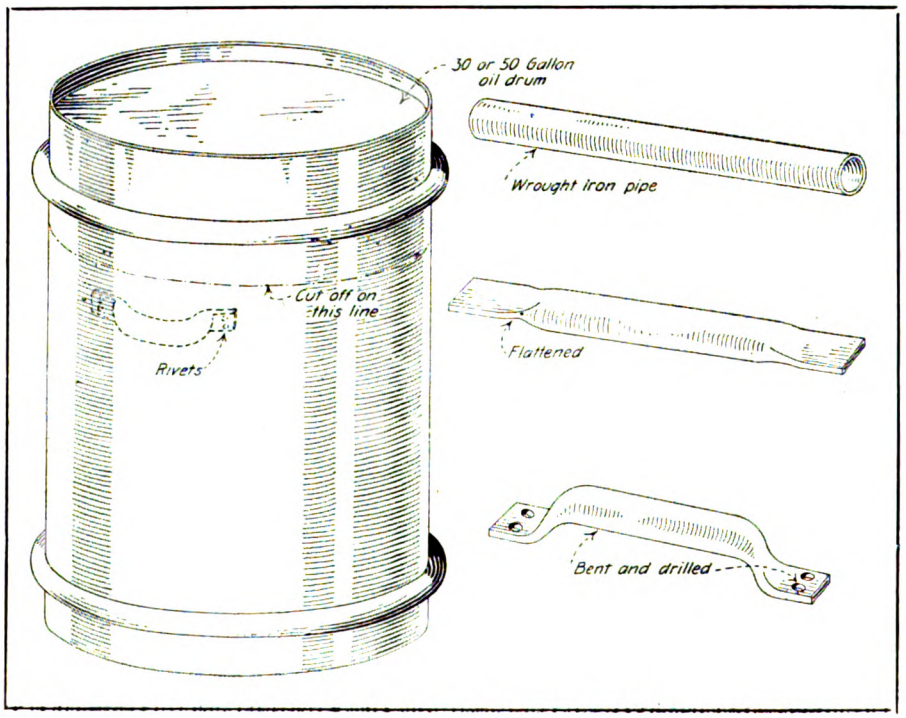
Kansas City, Mo. C. O. SANDSTROM.

Making Heavy Refuse Containers from Oil Drums

ALTHOUGH steel oil drums can usually be returned for credit, it is sometimes of advantage to use them for making special tote barrels or refuse cans for heavy material. Their special advantage lies in that they are made of somewhat stronger and heavier metal than can ordinarily be obtained in purchased refuse containers. For convenience they should be fitted with handles made of sections of wrought-iron pipe with the ends flattened out, bent and drilled as shown at the right in the sketch. These handles are riveted as shown.

The top section of the barrel may be cut off at any point, but it is usually best to cut it below the bulge, as indicated in the drawing. If these containers are to be used for very heavy material the barrel may be cut in two in the middle and made into two containers of equal size and the handles attached lower down.

Washington, D. C. G. A. LUERS.



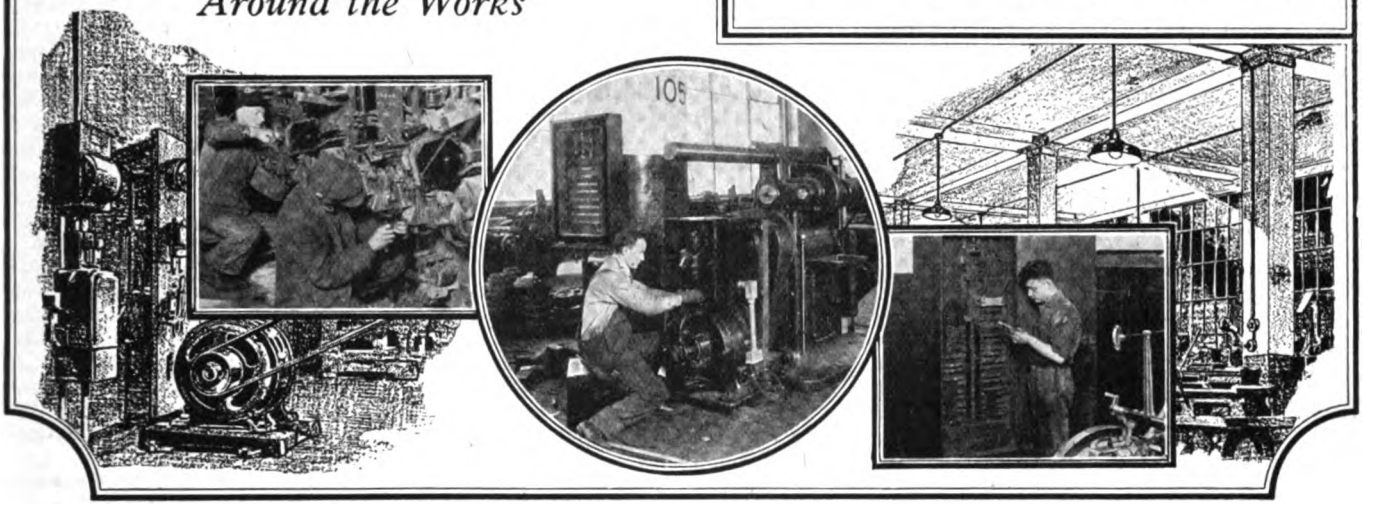
Extra heavy refuse containers or tote barrels may be made from oil drums by cutting off the ends and riveting on handles.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Method of Grounding Circuits to Protect Maintenance Men

IN A paper on safe operating practice with regard to electrical devices, presented at the Safety Congress recently held at Louisville, Ky., G. F. MacWilliams, electrical engineer of the Pennsylvania Coal & Coke Corporation, Cresson, Pa., spoke of the importance of grounding and short circuiting supposedly dead circuits before attempting work on these circuits. Mr. MacWilliams had the following to say in connection with this subject:

"Ground connections should be made to provide safety to equipment, discharge of abnormal potentials, and for providing a path for current leaks from equipment. Such means will reduce the hazards accompanying the operation of electrical apparatus. Sometimes it is not feasible to ground electrical apparatus and by doing so the hazards to the operator are increased rather than decreased. In any case, the grounding of equipment supports, etc., must be understood to be done for the protection of the operator from shock should these parts become charged without the operator's knowledge.

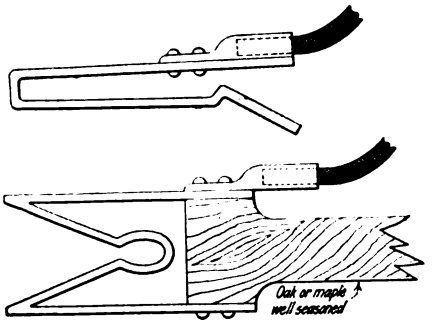
"Grounded frame parts will increase the danger of shock to the operator should he make contact between current-carrying parts and grounded frame parts.

"If oil switches were designed so that it would be necessary to open the switch before a short circuit or ground could be applied, a great step toward protection of operators would be accomplished.

"In short circuiting and grounding compartment-type switches, the ground connection should be made first. If the doors on the compartment are hinged at the top, do not remove them but swing them forward sufficiently so that you can reach by them and apply the connection to the switch. By this procedure the door will act as a barrier in case the switch is charged when it was thought to be dead.

"When men are working on lines, the conductor should be grounded and short circuited. The ground connection should be made first, and the short-circuiting devices applied afterwards. This should be done whether the work is to be performed inside the plant or outside on the line. For this purpose flexible cable not smaller than No. 6 should be used. For station work, one end of the cable should be fitted with a clip, as shown in the accompanying diagram which hooks over the ground bus and locks in place. On the other end of the cable a set of spring clips fitting the contacts on the line terminals and mounted on wood handles should be used. For grounding outside line wires a piece of ¾-in. pipe should be used not less than 5 ft. long with a connection head on one end and a point on the other.

"A clip that is similar to the one shown in the lower part of the accompanying diagram, made of copper and mounted on wood handles should be used for attaching to the line wires."



These clips are used for making ground connections to lines before maintenance work is started on the lines.

The upper clip is made to hook over the ground bus and is connected by No. 6 flexible cable to the lower clip which is hooked to the line wire or disconnect switch.

Motor Inspection Form Helps in Training Inspectors

NO ONE who has had any experience in inspecting equipment will deny that it is dirty and oftentimes disagreeable work. It requires a man who has judgment, brains and persistence. Such men are not easy to find. Also, it is not always good policy to turn even a good man, particularly one who is new to the plant, loose on a job and trust to him to inspect everything that should be looked after. It is very easy for an inspector to overlook certain pieces of equipment or elements thereof—and it is human nature to

Form 1604

INSPECTORS SHEET

Motor No. ____ H. P. ____ Bldg. ____ Floor ____ Date ____

Inspected by ____ Approved by ____

Has Motor been oiled?	Yes	No
Has Motor been cleaned?	Yes	No
Are Oil Rings turning and carrying oil?	Yes	No
Are Bearing Bolts tight, Pulley end?	Yes	No
Are Bearing Bolts tight, Commutator end?	Yes	No
Is Pulley tight on shaft?	Yes	No
Does Belt run straight?	Yes	No
Are Field Leads well insulated?	Yes	No
Does Field Coils need painting?	Yes	No
Does Armature need painting?	Yes	No
Air Gap between Armature and Topfield Pole?	Yes	No
Air Gap between Armature and Bottomfield Pole?	Yes	No
Does Commutator spark?	Yes	No
Are Brushes short?	Yes	No
Are Brushes chunked?	Yes	No
Are Brushes parallel with Commutator Bars?	Yes	No
Are Brush Holders properly spaced?	Yes	No
Is Brush Tension correct?	Yes	No
Are all Wires properly taped?	Yes	No
Are all Terminals tight?	Yes	No
Are Fuses right size? Put down size	Yes	No
Is Switch in good condition?	Yes	No
Does Rheostat Handle release?	Yes	No
Are Rheostat Contacts burned?	Yes	No
Does Starting Apparatus need attention?	Yes	No
Are all Wires in good condition?	Yes	No
Is Oil clean in Auto Starter?	Yes	No
Does Auto Starter Handle release?	Yes	No
Does Auto Starter Handle hold over?	Yes	No
Is Auto Starter grounded?	Yes	No
Is Motor grounded?	Yes	No
Are Drum Contact burned?	Yes	No
Are Finger Contact burned?	Yes	No
Does Controller need attention?	Yes	No
Is Controller grounded?	Yes	No
Does Oil Breaker need attention?	Yes	No
Location of Oil Breaker or Switch R. S. R.		
Use 111 Shed		
Burritt Sub. Sta.		
Use Dept. 300		

This sheet helps the motor inspector by showing him just what to do. It also serves as a valuable record of the condition of the equipment.

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slight the more difficult or disagreeable parts of a job.

We have drawn up the motor inspection form shown in the illustration to help us train our inspectors in the work; also to help the inspectors to do a good job. As will be seen, this form covers about all the points that should ordinarily be checked during the inspection of a motor so that little or nothing is left to the memory of the inspector. As each item is gone over, the inspector puts a check mark in the Yes or No column. When the sheets are turned in to the maintenance department, we have a very good record of the condition of the motor and its auxiliary equipment.

As inspectors we select men who have good, common sense and are thoroughly honest and give them these sheets to help them to know what to look for. With the help of these forms and such instructions as may be necessary or advisable to give them we have found that it requires only a few weeks to make a good inspector.

Power Engineer, The Stanley Works, New Britain, Conn. C. H. HART.

Method of Locking Compensator Handle to Prevent Starting Motor

THE device shown is used by the Canada Cement Company, Ltd., Montreal, Canada, to lock the operating handle of a compensator so as to prevent starting the motor while someone is working on the drive or the driven machine.

As can be seen, the device consists of a small piece of sheet steel and a wooden arm which is hinged to the support holding the compensator. The wooden arm is slotted as shown in the right-hand illustration so as to receive a metal plate, which metal plate has drilled in it one large hole that fits over the handle of the compensator. In addition there are several small holes, into which padlocks may be locked, as shown in the left-hand picture.

To make the wooden arm stronger and to prevent wear, one side of the slot is reinforced with a slotted plate as can be seen in the right-hand illustration. The metal locking plate is fastened to the wooden arm by a chain, so as to prevent it from being lost when not in use.

This locking device for a compensator can be very easily made and installed.

The construction of this device is shown in the two illustrations, which were furnished by the National Safety Council. Note that the device will accommodate four locks; thus as many as four men or gangs may be working on the motor, drive or machinery driven by the motor and there will be no danger of the motor being started until each of the four men or gangs have completed their work and removed their individual lock.

Designating Fuse Capacities by Different Colors

THOSE who are engaged in electrical maintenance work know by experience that machine operators are, as a rule, not familiar with fuse capacities. To them a fuse is a fuse, and if a cartridge fuse fits the clips, they assume that it is the proper size.

It is advisable to have machine operators practice a "hands-off" policy on electrical equipment of all kinds unless conditions are such that the operator can save time by replacing blown fuses. Then he must know what he is doing.

Frequently, there are times in all industrial plants when a fuse is blown by too rapid starting of a motor, or through other causes, and when the operator notifies the electrician he is unable to give the capacity of the fuse. If the plant is so large that the electrician can not remember the capacity of each fuse he must either take a supply of different sizes with him, or else go to the blown fuse to ascertain the capacity and then go back to the supply room to obtain a fuse of the proper capacity.

A fuse identification scheme which is very convenient involves painting a colored stripe or circle near the clips of all motor or other fuses, the fiber tubes of the corresponding fuses being painted the same color. When a fuse blows it is then a simple matter for the operator to call the electrician and tell him that a "yellow fuse" has blown.

The following color scheme is used in one plant which operates at 250 volts and covers all of the usual sizes used in a plant of this kind:

For 0-30-amp, ferrule type cartridge fuses:

5 amp., white—called Little White.
10 amp., black—called Little Black.
15 amp., blue—called Little Blue.
20 amp., green—called Little Green.
25 amp., red—called Little Red.
30 amp., yellow—called Little Yellow.

For 31-60-amp. ferrule type cartridge fuses:

35 amp., white—called Big White.
40 amp., black—called Big Black.
45 amp., blue—called Big Blue.
50 amp., green—called Big Green.
55 amp., red—called Big Red.
60 amp., yellow—called Big Yellow.

Some plants may not make use of all of the fuse capacities shown, but this tabulation gives a general idea of the scheme, which should be worked out to suit the conditions. For instance, a 110-volt installation would use larger-capacity fuses for the same power delivered, while a 440-volt installation would use smaller fuses.

This color scheme also serves as a check whereby the head of the department can see that the proper size of fuse is being used, simply by comparing the color of the marking stripe or circle with the color that has been painted on the fuse.

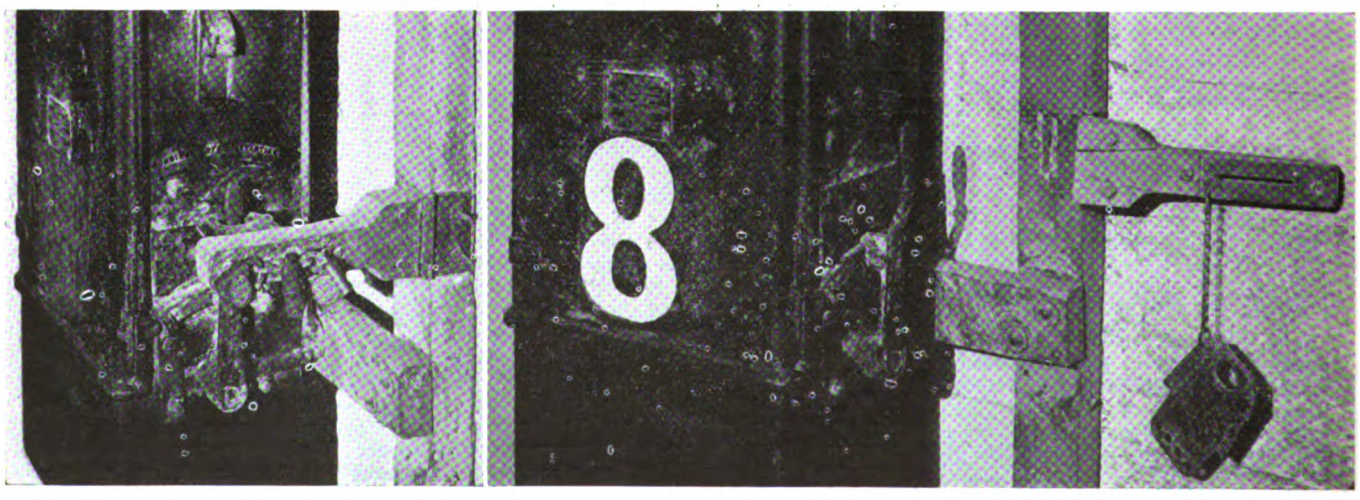
When renewable fuses are being used it is imperative that the proper-size links be placed in the different-colored holders. A renewable fuse of the Federal type with the capacity marked and in plain view at all times, even though the fuse is in the clips, lends itself admirably to a cross-check by the color scheme.

Plattsburg, N. Y. A. W. OPPMANN.

Method of Handling Installation of New Switchboard

DUE to the increased power demands, it recently became necessary for us to rearrange the power lines and install a new switchboard. Inasmuch as this was a job of considerable magnitude the manner in which the work was handled may be of general interest.

The old switchboard was in an unhandy place, being near a Corliss engine flywheel; also, it was not complete,



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having no meters of any kind, no overload relays, no bus-bars or suitable switches, and no capacity for additional feeders.

It was built of a few 3-in. wooden strips on which were mounted a limited number of porcelain cleats to hold the small-sized feeders, some single-pole cutouts, and some loose-hinged, 100-amp. three-blade switches. In short, it was too small and unsafe.

With the old arrangement the conductors were carried up through the roof in conduit, and thence to the various other buildings on low wooden horses. Many new motors were to be installed, and lighting lines re-arranged, so it was deemed necessary to provide a better outlet for the increased number of lines coming from the new switchboard.

The new switchboard, shown in the illustration, was designed and completely built by the General Electric Co., even to wiring the goose-neck lamps on all of the upper panels. We had in stock no material from which to construct such a board; besides our electrical force was too busy with daily maintenance and repairs to do more than to assemble the switchboard, when received.

The initial cost of the switchboard was considered only on the basis of capacity, efficiency, and completeness. We specified that it be shipped complete for assembling by our electricians, as it was desired to operate it immediately upon erection. When we were making the plans the management issued a simple "cast-iron" warning that no complaint as to incompleteness or inefficiency was to be voiced by anyone, superintendent, chief electrician or electrical workers, after the installation of the board, as it was desired to have the job done up properly once for all time.

It was specified that generous sized bus-bars, oil switches of 200-amp. capacity and terminal lugs be provided to care for loads likely to be carried for at least five years ahead. It was also specified that there should be no live parts on the front of the power panels of the 440-volt system, that overload protection be afforded by time-limit relays, that only two circuits be connected to each power panel, and that every power circuit have only one ammeter in its three-wire, three-phase line.

The panels were to be built down to the floor, the lower ones to take wattmeters later on.

The new board is 18 ft. long and 6 ft. 4 in. high, with panels 2 ft. wide. It is set 4 ft. from the wall, and all power and light lines are carried straight up through an opening in the roof and into a frame wire-tower, from whence they extend in different directions to the various buildings and other departments. Arms are used on the corners of buildings, thus eliminating the wooden horses.

Current is purchased at 13,000 volts and is stepped down to 440 volts for the motors, and again stepped down through smaller transformers to 110 volts, three phase, for lighting.

The first right-hand panel is for 110-volt, three-phase a.c. lighting. The last two panels to the left are for 125-volt battery charging, one of the panels controlling a belt-driven generator and the other a synchronous motor-generator set. These panels can be coupled with an equalizer to care for a total load of 800 amp. at 125 volts.

The second panel from the right carries the main power oil switch, which connects directly to the bus-bars, thus providing a quick and handy means of shutting off all power in an emergency.

The third panel from the left carries the synchronous motor starting switch and compensator. All the intermediate panels are for 440-volt power, and have two a.c. ammeters, two sets of overload relays, two 200-amp. oil switches, and one pilot lamp.

A ground detecting voltmeter with a testing plug is provided on the fourth panel from the left, so that ground readings may be taken on all three phases of the power lines.

Overload time-limit relays are used on the power panels, and fuses on the lighting panel. The power circuit ammeters are connected to small instrument transformers set in line with the copper feed bars between the oil switches and the main busbars located above.

The five motor feeder panels have a total capacity of 1,000 h.p. at 440 volts. The lighting panel, at the extreme right, carries six, three-wire switches with a total capacity of 600 amp. at 125 volts.

Each lighting switch has a capacity of 100 amp., and each power switch will carry 100 h.p. Many lines that were formerly carried along the ceiling of departments adjacent to the engine room have been turned up into the tower and are run out-of-doors, so as not to take up needed room inside the building. The lighting lines are No. 6 and No. 00. Many of the power lines are No. 4 and No. 4/0. The 125-volt d.c. cables to the storage battery department are 300,000 circ. mil, as are the 440-volt main feeder cables from the transformers. Weather-proof and rubber-covered wire is used over the roofs, and white slow-burning up into the wire tower.

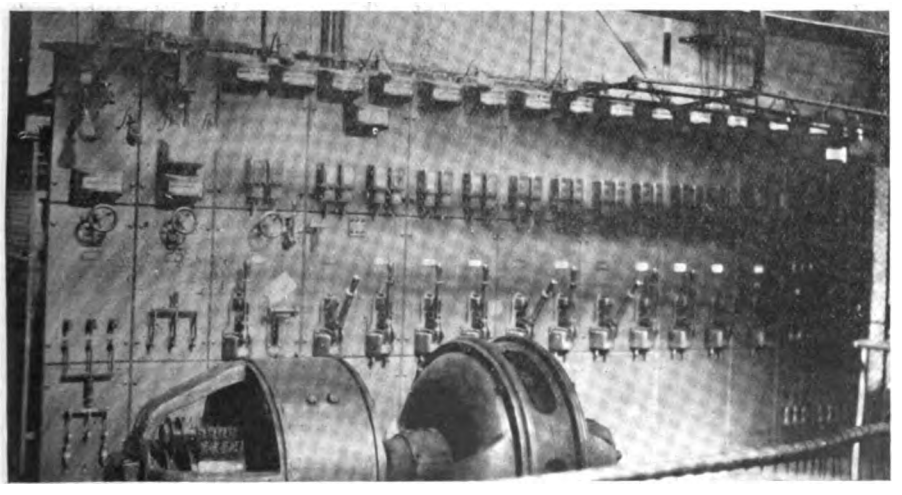
The whole switchboard frame is grounded by a No. 4/0 conductor carried out through the engine room wall, to an alley where the ground is very moist, and there bolted and soldered to two copper plates each 2 ft. long and 1 ft. wide, buried in a barrelful of coke some 5 ft. under ground.

As the switchboard stands, it has reserve capacity for years to come, looks very neat, is strongly built and practically fireproof, slow-burning wire being used at the rear. It is handy and safe to operate, takes automatic care of overloads, and has plenty of room for a worker to make the required connections at the rear.

The price of its installation was never regretted by our company, as no expense was spared to make it electrically perfect and with sufficient capacity.

New Britain, Conn. H. S. RICH.

New switchboard, designed for ease in making future extensions, which replaced an obsolete installation.



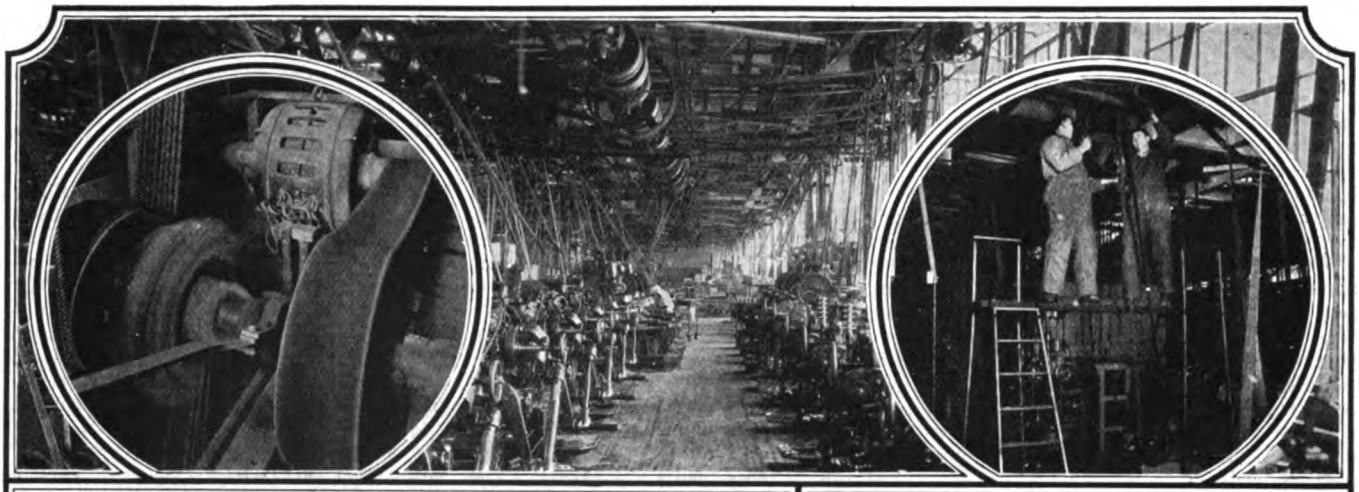
Routine for Handling Fuse Renewals on the Night Shift

IN A PLANT which covers a large area and operates 24 hr. a day, only one or two electricians are maintained on the night shift. It frequently happens, however, that a fuse must be changed during the night. As it often requires some time to locate these electricians at night, in case of an emergency, the foreman of each department is instructed on how to change a fuse and is provided with a supply of fuses of the various sizes required. To aid him in selecting the right size of fuse, there is stenciled on the front of each fuse box the ampere rating of the fuse to be used.

In addition to this, the foreman must in each case report the fuse removed and its location. Members of the electrical department on the day force immediately check up on each fuse so reported to be sure that the correct size is used. While there may be some objection to this method of handling fuse renewals, it has the justification that it is necessary to make renewals quickly so as to get the machine in operation again as soon as possible, as this is a continuous process.

Chicago, Ill. E. B. F.

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Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Increasing Size of Mounting for Larger Motor

SOMETIMES, because of an increase in production or difference in material handled, it is found necessary to replace a motor with one of a larger size.

If the machine has a bed plate built for only one size of motor, the task of putting in a larger motor may be somewhat troublesome.

In the accompanying illustration of a machine for charging pipe into a welding furnace, it was found that in charging the larger sizes the motor was too small to push the pipes into the furnace fast enough. The motor then in use was a 15-hp. series-wound, mill-type motor.

The gear ratio between the motor pinion and the gear on the countershaft was changed, but this increased the load on the motor and lowered the speed still more. Hence, it was decided to replace the 15-hp. motor with a series-wound, mill-type motor rated at 27 hp.

The charging machine bedplate for the motor was not large enough to take the 27-hp. motor; so a 1-in. steel plate, large enough to receive the new motor, was drilled to fit the drilling plan of the new motor, and then placed on the old bedplate, as shown in the accompanying illustration. This plate was drilled to line up with the holes in the old bedplate, these holes were countersunk and the plate bolted down. The motor was then mounted on the new plate. The arrangement has so far worked satisfactorily for three years.

Indiana Harbor, Ind. H. W.

A 27-hp. motor replaced a 15-hp. motor on this pipe charger.

The mounting built into the machine was not large enough to accommodate the new motor; so a sub-base large enough to take the new motor was made of 1-inch steel plate. This was bolted to the old mounting as is shown in the illustration.

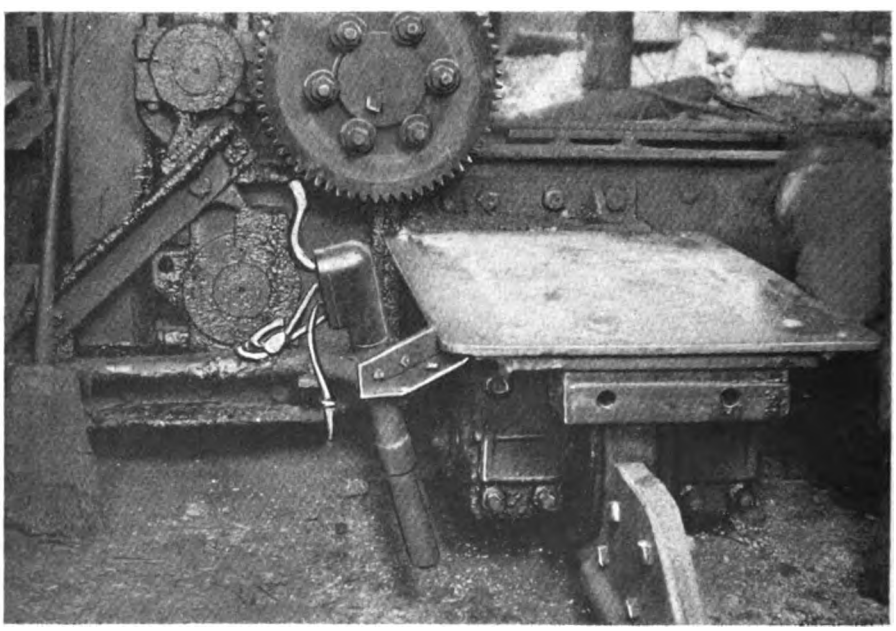
Precautions Necessary in the Use of Babbitt

IN THE purchase of babbitt metal, the purposes for which it is to be used should always be given or, better still, the proportion of antimony, lead and copper should be specified, if the buyer is thoroughly acquainted with the manufacture of this metal and knows what composition to use for given service conditions. For example, greater compressive strength is called for in heavy machinery than in line-shafting, light mill, and shop machinery. In the first case 80 parts of tin, 10 of antimony, and 10 of copper is a good proportion. In the latter case an alloy composed of 50 parts of tin, 25 of lead, and 18 of antimony gives good service.

Due regard for speed must be taken into consideration in the case of light bearings, but this is not so important in the heavier types, where the compressive strength is of first importance. Some engineers think that the quality of a babbitt metal is influenced by the order in which the components are added, but from authoritative tests which have been made, this has been proved a fallacy.

When babbitting a bearing the following instructions should be followed in order to obtain the best results:

In the case of a cast-steel or cast-iron shell, all old babbitt must be removed; this is best done by heating, then dipping in lye to remove dirt, and finally scraping off all rust and oxidation. Tinned shells of bronze or cast iron should be cleaned by heating in a pot of molten babbitt and when the old metal has melted out the tinned surface should be painted with a soldering flux and retinned by dipping in solder at about 650 deg. F. The portions which are not to be tinned should be painted with a thin mixture of clay and water. The shell to be tinned should be left



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in the solder long enough for the solder to run off, leaving a thin coating; then flux the surface again and give another dip into the molten solder. Should there be any untinned patches left the operation must be repeated.

Babbitt should not be used for tinning, because the higher temperature makes it hard to hold a thin skin of metal on the shell.

It is not advisable, unless absolutely necessary, as in case of a breakdown, to babbitt a bearing directly on the shaft, as the latter may be sprung. Therefore a mandril is used. This is heated to about 350 deg. F. and washed with a thin, clay-and-water solution, which dries off leaving a fine dust that gives a good surface to the bearing. The shell must be preheated not more than 200 deg. F.; otherwise it takes too long to cool and the heavier components of the babbitt will settle, making a bearing that is soft at one end and brittle and hard at the other.

Babbitt should be heated slowly and stirred at frequent intervals, adding graphite or charcoal to stop oxidation, and must be skimmed before using to insure that no scale or slag gets into the work. The average temperature at which the metal should be kept is around 865 deg. F., but this varies with different brands of babbitt.

In order to do a good job of babbitting, it is necessary to have clean tools, to preheat to the proper temperature, to have a well-tinned surface, and to maintain the metal at the correct temperature. The molten metal should be poured in a steady stream down the mandril, to avoid air spaces, using a ladle with a round spout, in preference to a narrow, sharp one.

In the case of heavy bearings, where there is a considerable thickness of metal to be poured, the shell should be dovetailed out or suitable anchorage provided, and should be tamped with rods while pouring.

When a bearing is poured directly, instead of having a shell, the above instructions will apply, but care should be taken to make provision for anchoring the babbitt to the bearing.

MAURICE C. COCKSHOTT.
Los Angeles, Calif.

Selecting Motors for Machines That Require Flywheels

IT FREQUENTLY happens in a shop using drawing presses, rolls, or other machines requiring flywheels, that the first motor application is unsatisfactory. In many such cases trouble has been experienced by the breaking of gears or other parts of the driven machine and in some cases the motor has been damaged or has had to be replaced with a larger or different type of motor. The majority of troubles of this sort come from the fact that full consideration has not been given to the special conditions existing with flywheel installations.

Machines having a duty cycle consisting of a short period of heavy load, followed by a period of light or idle load, use flywheels to deliver energy to the machine during heavy loads and to recover this energy from the motor during the period of light load. In order that the flywheel may deliver its energy to the machine it must be slowed down slightly and the energy thus delivered will be recovered as the motor brings the flywheel up to speed during light load. If a standard, constant-speed motor is used on such drives the results are often unsatisfactory. The motor running at constant speed does not allow the flywheel to deliver its energy to the machine, with the result that all the energy for the peak load must come from the motor and the supply line. This condition results in overheating the motor, excessive surges in the supply line, and often injury to the machine. On the other hand, a slight reduction in speed at the time of peak load has a cushioning effect upon all parts of the machine and greatly reduces the strains.

The unsatisfactory conditions outlined above may be eliminated by using a motor with more than the standard amount of resistance in the rotor circuit. In the case of squirrel-cage motors this may be accomplished by replacing the standard rotor with a high-resistance rotor, or by replacing the entire motor. The high-resistance rotor gives off more heat than the standard rotor and this condition must be taken into account if the rotor only is changed. It is generally better to replace the entire motor. The high-resistance motor may, in many instances, be of less horsepower rating than the standard motor and yet perform its work more satisfactorily. With slip-ring motors it is only necessary to connect some extra-heavy-duty resistors into the rotor circuit permanently in order to get the result desired. The writer has found many cases where a smaller motor with proper rotor has replaced a larger standard motor. In the case of direct-current motors the ordinary shunt motor can often be advantageously replaced with a compound motor so that the speed characteristics will be such as to allow the flywheel to do its share of the work.

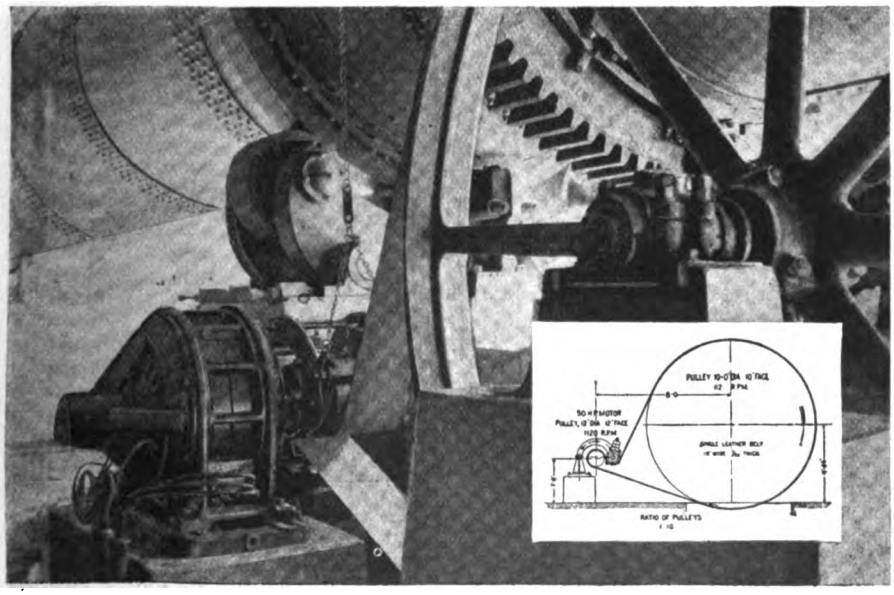
A recent practical application of this problem was brought to the writer's attention when a 750-hp., slip-ring motor on a rolling-mill drive behaved unsatisfactorily. A standard, constant-speed motor had been furnished and no account taken of the requirements of the flywheel. The result was that during the first few weeks of operation several machine parts were broken and the power company complained of severe power surges on the line supplying the plant. A suitable amount of heavy-duty resistance was permanently connected in the rotor circuit and the power surges were reduced from 1,250 hp. to 750 hp., while no further trouble was experienced from broken machine parts.

DEAN W. TAYLOR.
Power Engineer,
Central Indiana Power Co.,
Indianapolis, Ind.

Driving Belts on Short Centers With High Pulley Ratios

ORDINARILY large pulley ratios mean long belts with a wide pulley center distance. Even then if the pulley ratio is very large, such as the 10-to-1 ratio shown in the accompanying illustration, the necessary center distance will be so long that the belt will flop. Also, the small amount of belt surface in contact with the driving pulley will require some form of tension device to keep the belt tight enough to operate.

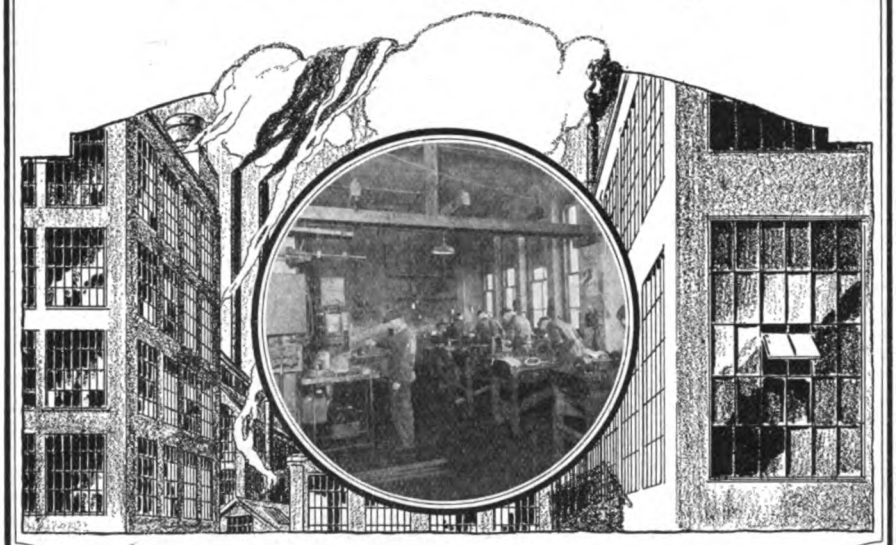
In the illustration a 10-to-1 ratio is obtained on short centers through the Lenix drive, as shown. This drive operates a Portland cement rotary kiln, 24 hr. a day under severe temperature conditions. Here a single 10-in. leather belt connects the 12-in. pulley on the 50-hp. motor to a 120-in. pulley on the drive of the kiln. Since the drive maintains its proper tension at all times irrespective of how the belt is affected by temperature conditions and also gives an increased arc of contact on the driving pulley, the life of the belt is not shortened either by slipping or by stretching through excessive tension. The special idler pulley may be raised when the drive is not operating, thus reducing the tension.



This rotary kiln drive operates with a 10-to-1 pulley ratio on an 8-ft. center.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

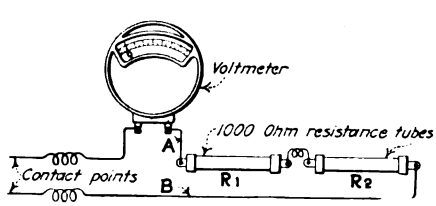
Defective Armature Testing Equipment Gave Puzzling Results

CONNECTIONS of a voltmeter and resistance used for making the bar-to-bar test on armatures in the course of production, are shown in the illustration. The test consists in passing current through the armature and taking, by means of the voltmeter, the drop from bar to bar all around the commutator. If all armature coils are alike and the commutator is faultless, all drops will be the same. A short-circuit will cause a small deflection or no deflection at all, according to whether the short-circuit is in the coil or in the commutator. A poor connection will cause a larger deflection and an actual open-circuit will throw the meter needle off the scale. The two 1,000-ohm resistance coils were used to hold normal deflections to a readable value.

In testing a certain series-connected, 4-pole armature, every contact with the commutator would throw the needle of the meter clear off the scale. In order to find out whether or not all abnormal deflections were of the same value, the current through the armature was greatly reduced; the deflections were then of uniform value. This meant that the trouble must be something unusual, such as a wrong connection that would convert the winding into a re-entrant winding, thereby placing several coils in series between every pair of commutator bars. Lifting several leads on opposite sides of the commutator and ringing out showed, however, that the connections of the coil leads to the commutator were counted off correctly. At this stage the electrician became interested and, in order to get all information first-hand, put the armature back into the bar-to-bar testing rack. Much to the surprise of everyone concerned, all deflections were now perfectly normal for that type and size of armature.

Investigation disclosed that the two resistance tubes (R_1) and (R_2) had become turned end for end in such a manner that wires (A) and (B) were touching, thereby cutting both of them out and placing the voltmeter directly across the testing leads.

Brooklyn, N. Y. J. A. HORTON.



A short-circuit between wires A and B cut out the resistance tubes and caused the voltmeter to indicate an open-circuit in all coils of an armature under test.

Unique Method of Heating Locomotive Wheel Tires for Removal

RECENTLY we had to turn some locomotive wheel tires which were badly worn and had several hard spots, but were still too good for the scrap heap.

This had usually been done by setting up the drivers in the lathe just as they were taken off the locomotives, and turning them, which process required five or six days. With the idea of cutting down the time taken to do the job, the tires were heated by the current induced in them from a coil placed around the wheel. This heating expanded the tires sufficiently to enable their removal.

A coil of thirty-five turns of No. 00 rubber-covered cable was wound and taped together as shown, a layer consisting of six turns, making the coil about 5 in. wide.

The form used for winding the coil was an old 44-in. pulley set up on a small shaft across a pair of horses, so that it was free to revolve; to give the right width and form to the coil several U-shaped brackets, made of ¼-in. by 1-in. flat iron were used. These brackets were spaced equally around the circumference of the pulley and with their backs to it, being held in place by the bottom layer of cable.

The coil was then tied with heavy cotton tape in about a dozen places to make it hold its shape, as it had to be used for taking off several sets of tires.

A. C. power was taken from two of the cables of a 100-hp. 550-volt compensator. A water rheostat was put in series in the circuit to control the current and a clamp-type current transformer with a 250-amp. range ammeter indicated the current used.

In operation, the driver was suspended on end with chain blocks as shown, so as to hold the lower wheel about a foot above the floor. The coil was held up around the tire as shown, blocks of wood being placed underneath to support it, and also to catch the tire when it came off and thus prevent the projecting outside rim from possibly grounding on the cable.

The coil had been made of such a size as to allow about ½ in. space between it and the tire; this space was packed with ¼-in. soft sheet asbestos to protect the insulation from the heat.

We found that a current of about 175 amps. applied for 40 min. expanded the tire enough so that it could be taken off by using a sledge and gradually raising the drivers with chain blocks.

This was a first experiment, but I am now convinced that if fifty or more turns had been used instead of thirty-five the tires could have been taken off much more easily, as they would have heated and expanded more rapidly, thereby communicating less heat to the



The tires were heated by induction, by placing the wheels within a coil of heavy insulated wire through which current was passed.

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wheel and not causing so much expansion of the latter.

After the tires were taken off they were turned on a boring mill in about 10 hours., or one-sixth of the time required to do the job in a lathe.

The same method can be used when putting the tires back on, and less heat is necessary as the wheel is not heated at the same time as the tire.

J. H. GALLANT.

Canada Cement Co., Ltd.,
Belleville, Ont., Can.

Rewinding Motor for Speed and Voltage Charge

AN INSTANCE of where both a speed and a voltage change were made in a motor came up recently, and readers of INDUSTRIAL ENGINEER may be interested in knowing how the change was handled. A Westinghouse, type CCL, 40 hp., three-phase, 220-volt, 720-r.p.m. motor burned out and the owner desired to have it rewound for 900 r.p.m. and to be used on 440 volts, increasing the horsepower as much as possible.

The stator had 150 slots and the original winding consisted of 150 coils of twenty-four turns each of one No. 14 d.c.c. wire, five coils per group, connected ten-parallel delta.

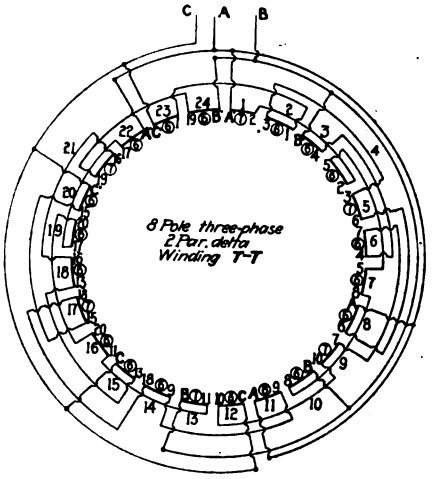
In attacking the problem the 900-r.p.m., 440-volt winding was considered as a voltage change as follows: The 720-r.p.m. series-delta voltage would be $220 \times 10 = 2{,}200$ volts and with the same number of turns per coil the series-delta line voltage for the 900-r.p.m. winding would be $(900 \times 2{,}200) \div 720 = 2{,}750$ volts. Now with 150 coils and eight poles there would be an odd grouping, or eighteen groups of six coils per group and six groups of seven coils per group, arranged as follows: 7-6-6, 6-7-6, 6-6-7, 6-6-6, 7-6-6, 6-7-6, 6-6-7, 6-6-6.

Then the only connections possible without killing or cutting out any coils are the series and two-parallel and to get a line voltage of 440 volts with a two-parallel delta connection, the series-connected winding would have to be good for 880 volts. The turns per coil for a series-delta, 880-volt winding would be $(880 \times 24) \div 2{,}750$ equals 7.68 turns per coil. An eight-turn coil could be used and the chord factor changed to reduce the effect of the 0.32 extra turn per coil.

The ten-pole full pitch is $150 \div 10 = 15$, or 1-and-16, and the 1-and-13 pitch is $11 \div 15 = .73$ or 73 per cent pitch. The chord factor of the 1-and-12, ten-pole pitch is 180 deg. $\div 15 = 12$ deg. The sine of $(11 \times 12$ deg.$) \div 2 =$ sin 66 deg. or .91354. Then 73 per cent pitch for eight poles equals $(150 \div 8) \times .73 = 12.6875$ or the chord factor of the 1-and-13 pitch will be $150 \div 8 = 18.75$; $180 \div 18.75 = 9.6$ deg. Then $(9.6$ deg. $\times 12) \div 2 = 57$ deg. 36 min. and the sine of this equals .84433.

The eight-turn coil, series-delta, 900-r.p.m. line voltage should be $(8 \times 880) \div 7.69 = 915.45$ volts, and with the 1-and-13 pitch the voltage would be $(0.84433 \div 0.91354) \times 915.45$ equals 835.8 volts. The 1-and-14 chord factor would be $(13 \times 9.6) \div 2 = 62.4$ deg., or sin 62 deg. 24 min. equals .8862 and the line voltage would be $(.8862 \div .9135) \times 915$, equals 887.64 which is alright.

The turns per coil have been reduced to eight or one-third the original; the copper should be increased three times, or the new coil can be wound with eight turns of three No. 14 d.c.c. wires in parallel, pitch 1-and-14, connected two-parallel delta for 440 volts. The diagram shows the connections.



Connections and grouping of coils in motor which was rewound for combined speed and voltage change.

The horsepower rating at 900 r.p.m. will be $(900 \times 40) \div 720 = 50$ hp. The motor will then draw 64 amp. per terminal.

The new data will, therefore, be 50 hp., three phase, 60 cycles, 900 r.p.m., 840 r.p.m. full load, 440 volts, 64 amp. per terminal. There will be 150 coils of eight turns of three No. 14 d.c.c. wires in parallel per coil, pitch 1-and-14, connected two-parallel delta.

Pittsburgh, Pa. A. C. ROE.

Simple and Efficient Device for Undercutting Mica

THE necessity of undercutting the mica of commutators on certain types of machines is well recognized and a number of devices have been brought out for this purpose. However, the price of an undercutting machine that can be adapted to all conditions is oftentimes more than a small repair shop can afford to pay. For this reason the device described below was built in one shop, and although inexpensive, it has given good service.

This undercutting outfit consists of a ⅛-hp. motor, which could be either a.c. or d.c., depending on the current supply, a flexible shaft with a 3-jaw chuck attached and a milling cutter.. The accompanying illustration shows the apparatus assembled and gives a good idea of the flexibility of the shaft, also the ease with which it may be handled. The shaft shown here was purchased from the Stowe Mfg. Co., Binghamton, New York. It is encased in a heavy leather sheath and may be operated in almost any position desired. Therefore, it is rarely necessary to remove any of the brush mountings, even on the smaller motors, during the operation of undercutting.

The chuck is simply a 3-jaw drill chuck and will be furnished and attached by the manufacturer of the shaft in accordance with your specifications. The milling cutter is a duplicate of those used by dentists and may be purchased from Ransom & Randolph, Toledo, Ohio, in various diameters and widths of teeth. The cost of the outfit complete was approximately $30.

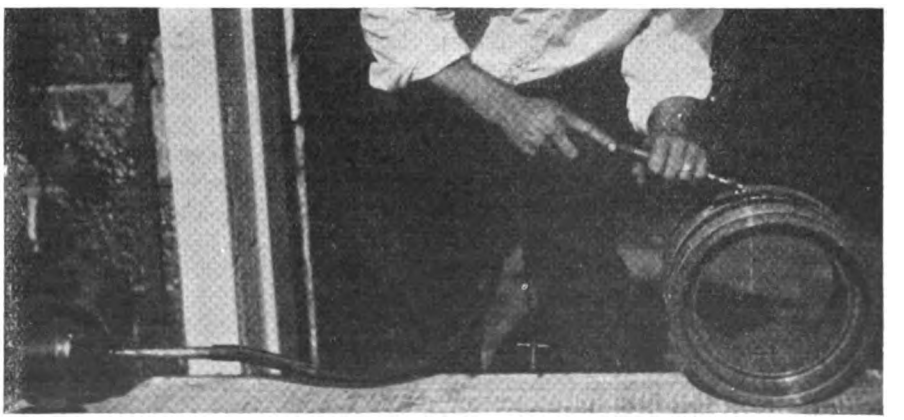
Our experience with these cutters has been very satisfactory, and we have found that under ordinary conditions the life of a cutter ⅞ in. in diameter is between 85 and 95 linear feet. The length of the shank of this cutter is sufficient to permit a good clearance of the chuck even on large commutators.

The efficiency of the device is shown by the fact that the time required to undercut by hand a commutator 9¾ in. long containing 241 bars, with the mica flush, was 12 hr. and 12 min., whereas another commutator of the same size and identical in every respect was undercut by this outfit in 1¼ hr.

This outfit has the further advantage that it can easily be transferred from one place to another, as it is very light in weight. Also, it can be used as a portable grinder or drill while, owing to its construction, holes can be drilled in locations that would be very difficult to reach with most portable drills.

Cleveland, Ohio. ROYCE L. GRIMES.

This mica undercutting device consists of a ⅛-hp. motor which drives a flexible shaft on the outer end of which is a 3-jaw drill chuck that holds a dental milling cutter.



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Growth of Industrial Centers

(*Continued from page 11*)

These industries are the lumber industry, steel works and rolling mills, paper and pulp wood, cotton goods, blast furnaces, foundries and machine shops. The primary horsepower reported for these six industries combined amounted to 13,934,074 hp. or 47.2 per cent of the total of all industries. These same six industries report the primary electrical horsepower owned or purchased as 6,329,908 hp. Thus about 45 per cent of these industries were electrified. Of these, however, foundries and machine shops were about 95 per cent electrified. Iron and steel works, including rolling mills, were a little over 61 per cent electrified, although blast furnaces were only 15 per cent electrified. The lumber and timber products industry and the paper and wood pulp industry showed a very low percentage of electrification. The printing and publishing and rubber tires and rubber goods industries, although they do not rank among the largest industries, show a relatively high percentage of electrification.

The total primary horsepower of the 237,854 establishments in the United States reported as using power was 29,504,792 hp.; of this 16,317,277 hp. was reported as electrical, or 54.5 per cent of the total. This shows that the six largest power-using industries were, as a group, below the average for all industry. These six, however, contained the industries which show the maximum and minimum percentage of electrification for all important industries.

The total primary horsepower of all industry was first reported in the census of 1879; this was 3,410,837 hp. The percentages of gain for each ten-year census report up to 1919 were: 74.1 per cent, 70 per cent, 84.9 per cent and 58 per cent respectively. The primary electrical horsepower was not reported until 1889; it then stood at 15,569 hp. The totals reported for each succeeding five-year period were: 1899, 492,936 hp.; 1904, 1,592,475 hp.; 1909, 4,817,140 hp.; 1914, 8,835,970 hp.; 1919, 16,317,277 hp. All of these figures were taken from United States Census reports.

The development of better methods of generation and the availability of power have had an important part in the industrial growth of the United States in the past. Further improvements in methods of application and utilization will have a corresponding influence on future industrial development.

Three Large Manufacturing Units

(*Continued from page 5*)

couplings and automotive equipment.

In 1901, the Allis-Chalmers Manufacturing Company was organized by combining Fraser and Chalmers, E. P. Allis Company, and Gates Iron Works, which had been for some years leaders in the middlewest in supplying engines, pumps and other heavy machinery to meet the demands of industrial and mining developments of the central and western sections of the United States. It was natural to add electric generators to connect to the line of engines and the hydraulic equipment and also motors devised to drive the special machinery as electric drives became more in demand, thus enabling the company to supply complete equipment and drives for entire plants or mills under one contract.

Some of the lines in which this organization has specialized in the production of equipment for specific industrial needs are: Cement mills, crushing, mining and metallurgical plants, saw mills and heavy woodworking plants, flour mills, hoisting equipment, hydraulic and pumping units, air compressors, gas, oil and steam engines, power transmission machinery, steam and water turbines and electric generators and drives for special service conditions, found in connection with these industries.

Most of this heavy equipment is made at the main plant at West Allis, a suburb of Milwaukee, Wis. In addition, a large factory is maintained at East Norwood, a suburb of Cincinnati, Ohio, for the manufacture of smaller electrical machinery for the generation, conversion, transformation and utilization of electric power. About 6,200 employes are engaged at the two plants which occupy a ground area of approximately 172 acres with a floor area of 3,645,875 sq. ft. A total of 190 electric cranes are used in the two plants and 21 miles of railway track in and around the two plants facilitate the handling of the heavy machine parts manufactured therein.

Use of Industrial Partitions

(*Continued from page 26*)

out of shape this may interfere more seriously with the re-erection.

Another use of industrial partitions is to separate off the lavatories and wash rooms. In most cases it is necessary to totally enclose these from the remainder of the plant. Ordinary steel, however, cannot be used to advantage around toilets and showers because of the difficulty of coating it so as to prevent rusting because of dampness. There are some special alloy metals used which overcome this. One of these is a special copper-steel alloy; another is an aluminum alloy. Both of these are rust resisting and do not depend upon paint or other coatings to prevent oxidation.

In planning for any installation it is well to consider how essential is appearance. If the partitions are to be used largely for offices, a better appearing unit would be more desired than would be necessary if it were used merely for factory stockroom or similar work. The appearance desired or considered necessary will no doubt have its effect on the price.

In planning an installation, the industrial man must first take into account the same points which he uses in getting an estimate from the manufacturer. These will also help him to get a better understanding of what would be expected of him. These factors which are required in an estimate as given by one manufacturer are listed in the table on page 26 and are practically self-explanatory so are not discussed further here. In any case it is usually best to adopt one manufacturer's equipment as standard, if possible.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: Audubon Wire Cloth Co., Inc., Audubon, N. J.; The E. F. Hauserman Co., Cleveland, Ohio; David Lupton's Sons Co., Philadelphia, Pa.; Lyon Metallic Mfg. Co., Aurora, Ill.; The Mills Co., Cleveland, Ohio; The Sanymetal Products Co., Cleveland, Ohio; Van Dorn Iron Works, Cleveland, Ohio; Henry Weiss Mfg. Co., Atchison, Kan.

In giving credit to the manufacturers who had co-operated in furnishing information and photographs for the article on, "Shelves and Racks in Industrial Storerooms," which appeared in the December, 1924, issue of INDUSTRIAL ENGINEER, the name of David Lupton's Sons Company, Philadelphia, Pa., was inadvertently omitted.

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Windings Having One Coil Per Slot

(*Continued from page 22*)

Fig. 7 shows an involute type of one-coil-per-slot winding. The name comes from the V-shape or involute character of the coil ends. Another illustration of the involute winding is shown in Fig. 8. The principal advantage of this winding is that all coils are of the same size and shape and that they require a comparatively small space for the coil ends. This type has the disadvantage, however, that due to the large number of relatively sharp bends, the coils are difficult to insulate and assemble in the armature.

Figure 9 shows an involute winding used on a three-phase rotor for an induction motor. This rotor has 180 slots with 90 coils forming ten poles. There are $(10 \times 3) \div 2 = 15$ dupole-phase groups having six coils each. Inspection of Fig. 9 will show that one side of a coil is longer than the other. In the group of six coils, the six long coil sides form one pole while the six short sides form another pole.

All of the windings that we have considered have been lap-wound, single-layer, half-coiled or consequent-pole windings, having only one coil per slot. In an early issue, we will take up one-coil-per-slot windings such as are used in turbo-generators and one-bar-per-slot windings as used in large motors carrying heavy currents.

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Link-Belt Company, 300 West Pershing Road, Chicago, Ill.—Book 580, entitled "Link-Belt Electric Hoists and Overhead Traveling Cranes" illustrates the construction and operation of the various types of Link-Belt equipment and gives dimensions of the various capacities and types.

The Truscon Laboratories, Detroit, Mich.—A 33-page booklet illustrated with 19 photographs and sketches and entitled, "Science and Practice of Integral Waterproofing," tells in a simple and popular manner why concrete is porous and how it absorbs moisture, and explains the action of the various Truscon repellant waterproofing compounds.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio.—Bulletin 314 describes the various automatic reclosing circuit breakers of the switchboard type, and auxiliary relays for the protection of direct-current circuits. A complete description, including dimensions and specifications with illustrations, is given for each of the various types.

Spaulding Fibre Company, Tonawanda, N. Y.—A 48-page booklet describes the numerous fibre products produced by this company, including Spaulding Bakelite-Duresto which may be supplied in sheets, tubes or rods for electrical purposes.

The American Transformer Company, Newark, N. J.—Bulletin 1030 describes several different types of industrial transformers for special purposes, such as 50,000-volt testing transformers, transformers for resistance heating, brazing and welding machines, furnace transformers, rivet-heating transformers, reactance coils, and ozone transformers.

W. A. Jones Foundry and Machine Company, 4401-51 West Roosevelt Road, Chicago, Ill.—Catalog 31 entitled, "Jones Power Transmission Machinery," covers shafthangers, pillow-blocks, couplings, collars, belt tighteners and similar items. Catalog 32 entitled "Jones Sprocket Wheels and Chain Belting" covers a full line of sprocket wheels and chain belting as well as chain tighteners, elevator boots, buckets, head wheels and similar equipment. Both catalogs are well illustrated, and list prices, tabulate dimensions and give complete specifications on all items.

Roeper Crane and Hoist Works, Inc., 1720 North Tenth St., Reading, Pa.—Form 112 describes the Roeper (formerly Reading) electric, Type R hoist with spur gear and worm drive; the capacity is from 500 to 4,000 lb. These hoists are single-speed, cord-controlled.

Black and Decker Manufacturing Company, Towson, Md.—Recent literature describes a new Black & Decker No. 3 reversible socket wrench and also the No. 2 electric tapper. Announcement is also made of a special 6-in. drill grinder.

General Electric Company, Schenectady, N. Y.—A 12-page booklet, Y-2019, describes the new Type A, welding electrode, gives details of the construction and characteristics and instructions for its use. Numerous tests on welding cast-iron specimens and on deposited metal specimens are described.

Pittsburgh Transformer Company, Pittsburgh, Pa.—Bulletin 2035, describes the construction and other features of Pittsburgh single-phase and polyphase power transformers.

Alexander Brothers, 14 South Street, Philadelphia, Pa.—A folder describes "Tentacular" suction belt which consists of oak-tanned leather belting to the underside of which are attached narrow, longitudinal strips, specially made of soft and spongy chrome-tanned leather. These are held in position by means of hollow rivets. It is claimed that the depressions or hemispherical pockets in the strip, having the inside of the hollow rivet as a body, act as suckers during use and cause adhesion of the belt on the pulley. This booklet describes other advantages obtained from the belting, the amount of power transmitted and gives formulas and other data for computing the belting required.

The Bryant Electric Company, 1421 State Street, Bridgeport, Conn.—A 202-page catalog entitled "Superior Wiring Devices" covers the complete line of Bryant supplies.

Renovatol Company, Mascher and Turner Streets, Philadelphia, Pa.—A circular describes "Renovatol" which is used to remove oil, grease or water from leather or canvas belts while operating at full load, and without removing the belt from the pulley.

Chas. A. Schieren Company, 30-38 Ferry Street, New York, N. Y.—A folder describes Duxbak leather belting, shows an unusual installation and also gives list prices.

Hasler-Tel Company, 461 Eighth Avenue, New York, N. Y.—A folder describes the Hasler speed indicator which can be used to find the revolutions per minute or surface speed in feet per minute directly and without calculation, as is ordinarily necessary when a watch is used.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin 1024 entitled "Graphic Instruments in the Pulp and Paper Industry" shows some of the numerous advantages and applications of such equipment in this industry.

The Hullhorst Micro Tool Company, Toledo, Ohio.—A folder describes the Hullhorst mica undercutting machine, in both portable and lathe types for industrial plants and its No. 10 size, for manufacturers of armatures and commutators. Special attention is given to the disc-type mica cutters which are made ¼ in. or ⅜ in. in diameter and in various thicknesses.

Foote Bros. Gear and Machine Company, 236-246 North Curtis Street, Chicago, Ill.—Catalog 25, entitled "Foote IXL Speed Reducers," is a 79-page book, which contains a complete description of the construction of the different types of spur- and worm-gear speed reducers and shows the type of reduction to which each is best adapted. Bedplate castings for mounting speed reducers and motors and several types of flexible couplings are also described, listed and priced. A large variety of installation are illustrated.

J. Struthers Dunn, 1109 Race Street, Philadelphia, Pa.—A leaflet describes a new style of relay and resistance designed for pressure and temperature control and so arranged that contact is made but never broken on the primary contact. These relays are designed for all voltages from 6 to 220 volts and will carry and break 20 amp. with a magnet coil that takes from 8 to 10 watts.

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The Sterling Varnish Company, Pittsburgh, Pa.—A reprint of a series of five articles on "Insulating Varnishes" which were published in INDUSTRIAL ENGINEER during 1924, has been prepared in pamphlet form and is ready for distribution. These articles were designed to appeal to the average shopman and describe in a practical, non-technical manner the best ways of applying insulating varnishes to obtain given results.

Revolvator Company, 336-352 Garfield Avenue, Jersey City, N. J.—A circular entitled, "How to Pile," illustrates and describes the advantages of piling boxes, cases, barrels, hogsheads, bales, crates, as well as bundles and packages, by special equipment designed for that purpose.

Crouse-Hinds Company, Syracuse, N. Y. —Folder 20 describes a line of safety switch condulets, tumbler type.

Pyott Foundry Company, 328 North Sangamon Street, Chicago, Ill.—A folder describes the line of Pyott hangers, bearings and hanger boxes and "red face" cast-iron pulleys and flywheels.

Standard Conveyor Company, North St. Paul, Minn.—Catalog 2 entitled "Wherever Conveying Is Done," illustrates a wide variety of Standard applications of conveying equipment in a number of industries.

Gifford-Wood Company, Hudson, N. Y. —Bulletin 24-A describes the construction and use of the portable flight conveyor for loading or elevating loose material. This may be driven by either motor or gasoline engine.

General Electric Company, Schenectady, N. Y.—Leaflet 67735-1 describes automatic switching equipment for sectionalizing and reclosing service on 275 volt d.c. mining and industrial service. This equipment eliminates general shut-downs caused by overloads as, in case of trouble, only the affected section is disconnected. As soon as the cause of trouble has been removed that section may be restored to service.

Weston Electrical Instrument Company, Newark, N. J.—A 100-page booklet entitled, "Electrical Testing in Industry" covers in a thorough way the use of testing equipment and the necessity, advantages and results which might be expected from making tests. This booklet was written by E. S. Lincoln, consulting electrical engineer, and discusses the subject purely from a practical operating standpoint. Numerous diagrams and methods of connection are illustrated as well as practical suggestions on overcoming the many difficulties which come up in conducting a test.

Norton Company, Worcester, Mass.—A monthly circular entitled "Norton Floors" describes numerous Norton installations. These floors are built especially to resist wear by using Alundum aggregate embedded in the concrete to a depth of approximately 1¼ in.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Circular 1705, entitled, "CL Carbon Circuit Breakers for Industrial Applications," describes equipment designed for use on 250-volt industrial systems and gives several new features in breaker design which have been incorporated in this new protective device.

Wagner Electric Corporation, St. Louis, Mo.—Bulletin 134 describes the Fynn-Weichsel motor, shows its construction and explains how it is able to correct power factor.

Condit Electrical Manufacturing Company, South Boston, Mass.—Industrial handbook 5005 covers a line of Condit safety air circuit breakers, oil switches, oil motor-starters, service switches and includes several handy tables as well as Underwriters' motor rules. This book also contains a description of the new Type N-4, manually-operated, oil motor-starter. This has overload protection, but is non-automatic.

Monitor Controller Company, Baltimore, Md.—Bulletin 106 describes the Monitor thermaload starter for small alternating-current motors. This is made in the automatic type, which may be arranged to permit control of the motor from a number of points, and also in a manually-reset type by which a motor may be stopped from a number of positions but started only from certain stations. Complete instructions for operation are included in addition to the description of the apparatus.

Chandler Machine Company, Ayer, Mass.—A booklet entitled, "Why Not Deposit a Part of Your Power Bill?" describes the construction, installation, lubrication and application of Chandler roller bearings for lineshafts and countershafts.

Lyon Metallic Manufacturing Company, Aurora, Ill.—Bulletin 209-B is a handbook of types and installation details for steel lockers. Considerable attention is paid to construction details and specifications of the various types. A large number of illustrations show how these may be used. Bulletin 104-A shows the various types of steel shelving, how they are constructed when shipped knocked-down and a number of the various combinations of shelving and drawer space which may be constructed from them. Bulletin 107 shows the commercial type of Lyon steel shelving.

Benjamin Electric Manufacturing Company, 847 West Jackson Boulevard, Chicago, Ill.—Bulletin 52 entitled, "Benjamin Industrial Lighting Equipment," in addition to describing and listing as well as pricing the various industrial and outdoor lighting equipment and devices, devotes several pages to lighting data and general information of interest to those who may be planning a lighting installation. Particular attention is called to the "Ben-ox" interchangeable devices, such as ceiling units, sockets, connectors, shade holders and reflectors for commercial and industrial lighting units which permit the quick removal of units for cleaning or for changing.

Sundh Electric Company, Inc., 5 Avenue C, Newark, N. J.—Bulletin 18 entitled, "Sundh Electric Control for Tire Pumps," describes the manual, automatic and combined types of control. This booklet also gives the regulations of the National Board of Fire Underwriters and the amendments adopted by the National Fire Protection Association.

The Foxboro Company, Inc., Foxboro, Mass.—Bulletin 96-1 describes the various indicating and recording pressure and other gages manufactured. A special bulletin illustrates the operation of the helical tube movement for controlling the recording device.

E. H. Freeman Electric Company, Trenton, N. J.—Catalog 8 includes a complete line of wiring devices, such as sockets, receptacles, rosettes, panel switches, plug and fuse cut-outs and other devices. Special charts of the interchangeable porcelain and glass shell line of sockets show the special bodies, caps and bases and gives a combination number for each of the various combinations.

Palmer Electric and Manufacturing Company, 175 Fifth Street, Cambridge, Mass.—Bulletin M-57 describes the universal service and industrial safety switch which receives the Underwriters' Classification AA. This has a special fuse cover which may be opened for changing fuses only when the switch is "off."

Ward Leonard Electric Company, Mount Vernon, New York.—Bulletin 57-revised describes and gives prices for the Vitrohm fractional horsepower armature speed controllers with an embedded resistor of fully enclosed type or of exposed contact type. Bulletin 58 describes the fractional horsepower starter with no-voltage protection for direct current motors. These are made for 115- and 230-volt motors rated from 1/50 to ½ hp.

American Blower Company, Detroit, Mich.—Bulletin 1613 describes the Ventura disc fans of standard stock sizes and types, gives their constructional features and application. These are pulley or motor-driven. Bulletin 1002 gives the standard stock sizes and type of Sirocco fans and utility blowers.

G. & W. Electric Specialty Company, Inc., 7440 South Chicago Avenue, Chicago, Ill.—A special folder describes the Types F and M underground distribution boxes for voltages up to 600 and the Type C box for voltages up to 15,000. These underground boxes are of standard construction. All boxes are given a 5-lb. air test which shows them waterproof.

Crouse-Hinds Company, Syracuse, N. Y. —Bulletin 2055 illustrates, describes and gives prices on the various types of Arktite circuit-breaking plugs and receptacles. In these the arc formed by pulling the plug is completely confined in a chamber of insulating material and it is impossible to form a short circuit or ground.

Albert and J. M. Anderson Manufacturing Company, 289 Eighth Street, Boston, Mass.—A bulletin describes the bus-bar or flat metal bender which is made in three sizes to take flat stock from ⅛-in. to ⅜-in. thick and up to 10 in. wide. This bender is held in a vise and will bend up to an angle of 90 deg.

Allen-Bradley Company, 491 Clinton Street, Milwaukee, Wis.—Bulletin 600 shows by charts the operation and various advantages claimed for the alternating current resistance starter.

Chandeysson Electric Company, St. Louis, Mo.—A group of bulletins describes the direct current motors and slip ring and squirrel cage alternating current motors of 1 to 100 hp., motor generator sets of 1 to 75 k.w. and electro-plating generators and motor-generator sets from 25 to 15,000 amp.

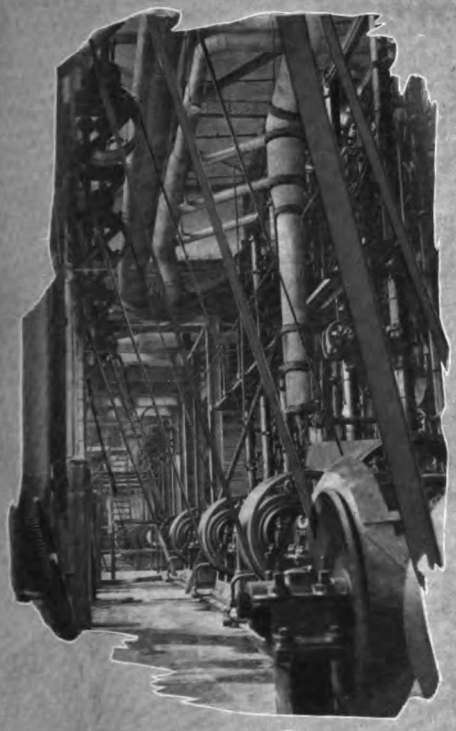
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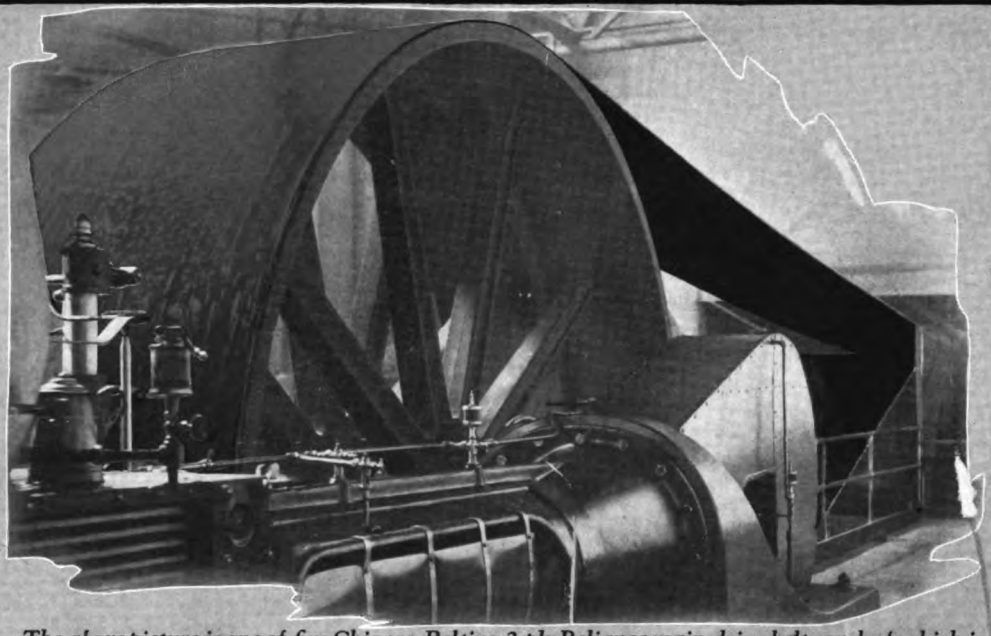
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Industrial Engineer

Devoted to the
ntenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories





The above picture is one of five Chicago Belting 3-ply Reliance main drive belts each of which is 72 inches wide, in five mills in one plant of a large cement mill. These belts were installed in 1904 and in the opinion of their superintendent are in good condition today with years of service ahead of them. So far they have lasted 21 years. In the cement industry one out of every two plants in the United States are extensive users of Chicago Belting belts.



The belting used by "BIG BUSINESS"

THE largest manufacturing institutions in most every industry are buying a much better-than-average type of leather belting. They are securing belting that is at least 25% better than the best belting of 10 to 20 years ago. The belting they use is not only better in most every way but it lasts longer and saves power and money.

This belting used by "big business" is Chicago Belting leather belting *made by the pre-tested method*—which method is believed by many large buyers of belting to be the most notable advancement of this century in leather belting.

A complete description of this advanced and economical type of belting will be sent to any belt user upon request. It may mean a material saving to you in your belt purchases and also will give you a marked increase in the efficiency of your belt transmission.

(Upper Picture) Chicago Belting Sea Lion belts on wet end of a paper machine in one of the big paper mills. In the pulp and paper industry where production is all important, Chicago Belting belts are used extensively.

(Lower Picture) This is a picture of the interesting Morgan Drive in the steel industry. The four big belts going over one pulley are all Chicago Belting Reliance brand 3-ply belts. Most of the large manufacturers of steel in the United States are regular users of Chicago Belting belts.

Chicago Belting Company

NEW YORK, BOSTON, PITTSBURG, CLEVELAND, MILWAUKEE, ROCKFORD — NEW ORLEANS, LOS ANGELES, SAN FRANCISCO, PORTLAND, ORE., SEATTLE, WASH., ATLANTA

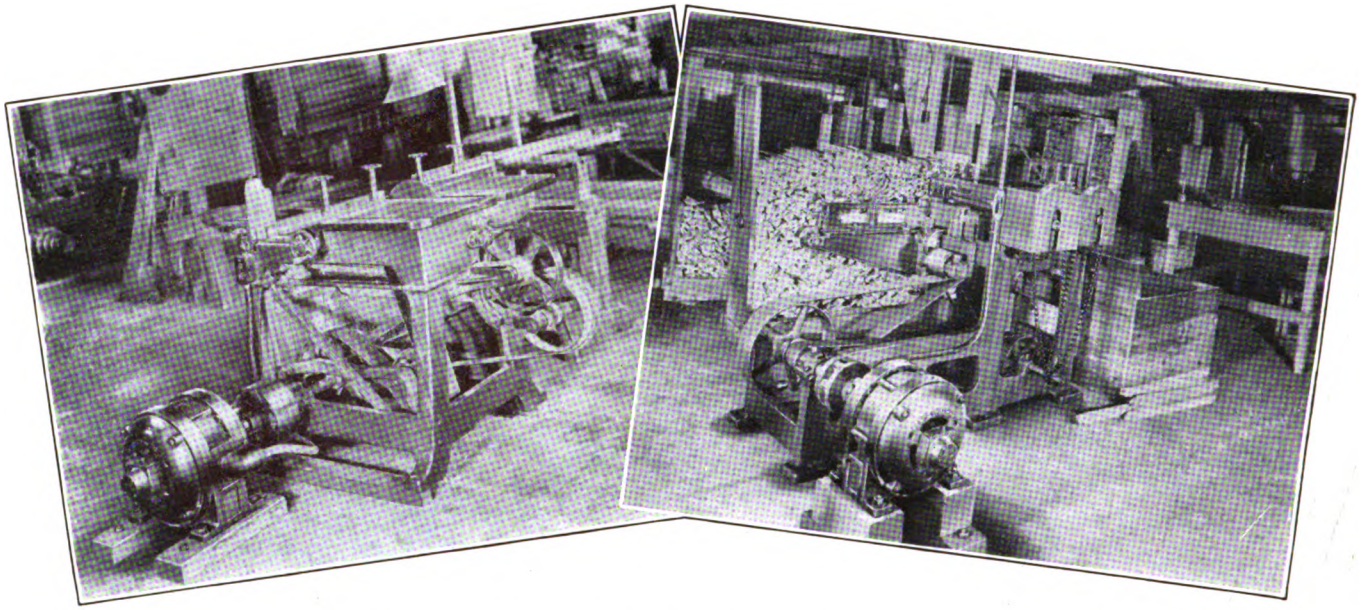
Manufacturers of Leather Belting

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CHICAGO, U.S.A.

Chicago Belting

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ALLIS-CHALMERS



Type "AR" Induction Motors drive woodworking tools

The illustrations show Allis-Chalmers Type "AR" Induction Motors driving working tools in the plant of the Watsontown Door & Sash Co., Watsontown, Pa.

These motors are of the all-steel frame construction, making them extremely rugged.

The method of ventilation results in even cooling and avoiding hot spots.

Write for more detailed information and bulletin.

PRODUCTS:

Electrical Machinery
Gas Engines
Steam Engines
Steam Turbines
Condensers
Oil Engines
Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
Mining Machinery
Metallurgical Machinery
Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
Air Brakes
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Farm Tractors
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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 83 Chicago, February, 1925 *Number 2*

Thanks! Many Thanks!!

You're a Lot of Good Fellows and Just the Kind I Like to Work With

I RECEIVED a lot of Christmas and New Year cards this year, wishing a Merry Christmas and a Happy New Year in the good old-fashioned way. All of these touched the spot far above where I keep my change and made me feel that, although Santa did not bring me a salary increase, I am rich in a thing that money cannot buy: namely, lots of honest-to-goodness friends.

A message I received from M. B. Urquhart of Denver, Colo., struck me as something good and sort of told me that Urquhart must be a good scout. His message was headed "Fellowship" and read:

It's a great thing, O my brothers, for a feller just to lay
His hand upon your shoulder in a friendly sort of way!
It makes a man feel queerish, it makes the teardrops start,
An' you sort o' feel a flutter in the region of the heart;
You can't look up and meet his eyes; you don't know what to say
When his hand is on your shoulder in a friendly sort of way!

It's a great thing, O my brothers, for a feller just to lay
His hand upon your shoulder in a friendly sort of way!
For the world's a curious compound with its honey and its gall,
With its care and bitter crosses; but a good world after all;
An' a good God must have made it—leastways, that is what I say.
When a hand is on my shoulder in a friendly sort of way!

Hundreds of you fellows who have read my stuff during the past three years have laid a hand upon my shoulder in just this friendly sort of way in the nice things you have said in your letters about me and the paper I am associated with. To all of you I want to express my appreciation and simply say that if you like my stuff as well as I like to know that you like it, we're even. Some of you have said a lot and some just a word or two, but I have seen every comment and hereby acknowledge all of them with special thanks to the following:

Nicholas J. Weiss who said: "I wish to take this occasion to thank Practical Pete and the rest of the gang out in Chicago for their efficient, faithful and last, but not least, helpful service through what I may christen The Practical Man's Friend —INDUSTRIAL ENGINEER. May I extend my heartiest good wishes for a Merry Christmas and a prosperous New Year."

C. Otto von Dannenberg, who said: "Tell Practical Pete that INDUSTRIAL ENGINEER is becoming a veritable treasure trove of useful information."



H. J. Achee, who said: "I have subscribed to lots of electrical and mechanical magazines but INDUSTRIAL ENGINEER is the best of them all by a large majority."

H. G. Lechner, who said: "I like the manner in which the various articles in INDUSTRIAL ENGINEER are written. They make you feel as if you were solving the problems with the writer."

Ira A. Bledsoe, who said: "I take pleasure in recommending INDUSTRIAL ENGINEER to my friends."

B. R. Glasscock, who said: "I am interested in motor installations and details of plant equipment as presented in INDUSTRIAL ENGINEER. Practical Pete is always good."

A. B. Lang, who said: "I am pleased with the service you give through INDUSTRIAL ENGINEER. It is a paper I would not be without."

C. E. Christoff, who said: "I have been a subscriber to INDUSTRIAL ENGINEER for two years and I would not do without it if I could possibly get it."

W. J. Schaffer, who said: "I am very much impressed with Practical Pete, but INDUSTRIAL ENGINEER is good all the way through."

W. H. Lewis, who said: "I am interested in the practical departments and anything by Practical Pete."

T. J. Frayno, who said: "INDUSTRIAL ENGINEER is the most practical magazine I have ever been able to get and I have tried them all."

That's enough! All of the rest of you said something equally nice to hear and I acknowledge your letters with blushes, for you have done yourself proud with appreciation that merits more hard work and just the best that in me lies. That you are going to get during 1925.

Practical Pete

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What Maintenance Includes and How It Is Handled

In the Groton and Cortland (N. Y.) Plants of The Corona Typewriter Company, Together With Details of the Work Done and of the Organization That Is Required

By C. D. CORWIN

Works Engineer, Corona Typewriter Co., Inc., Groton, N. Y.

THE maintenance organization in a mill or factory should be responsible for all lines of work, in the entire plant, on which efficient operating conditions depend. This may at first appear to be a very broad statement, but any production man knows to what an extent conditions of machinery, equipment, etc., affect his output and where the responsibility for proper working conditions is divided between several heads, there is always a great tendency to pass the "buck." The chief electrician can best handle all electrical equipment. The master mechanic can best handle all other equipment. In using the title master mechanic, I refer to a man who has practical experience and the better man he is if he has had a technical training. When the size of the plant demands it, there should be various divisions of the work handled, each with its foreman. For instance, machinery maintenance, tool maintenance, building maintenance, factory equipment maintenance, safety work, and so forth. Not all of the work of a maintenance organization can be strictly classified as electrical or mechanical for there is much important work that arises which calls for a knowledge of factory operation and plant construction. This work usually involves important changes, such as relocation of pipe lines and machinery to better facilitate routing of work. The maintenance organization should also have information on various types of roof coverings, concrete floors, removal of obnoxious fumes and wastes, etc.



C. D. Corwin, Works Engineer, Corona Typewriter Company, and President and Manager of the Corona Building and Improvement Company. His maintenance force is shown on the opposite page.

Maintenance and plant operation require men of practically every trade with the possible exception of paper-hangers and stonesetters. The man in charge of maintenance and plant operation should be broad-gaged, for he has as his main duties the selection and organization of the proper men to handle the many diversified problems which go to make up maintenance. He should so organize his force as to properly and efficiently operate the plant and to maintain all of it in first-class condition at all times. He should secure the confidence and co-operation of the men under his charge, to the end that every individual will have the company's interest at heart, and will be on a constant lookout to render better service to all departments. He should establish a suitable inspection routine in order to anticipate failures and to make the necessary repairs and adjustments before serious breakdowns can occur. Time spent on conscientious inspection and prevention of interruption to production pays big dividends and money may be saved and considerable lost time prevented by such regular inspection.

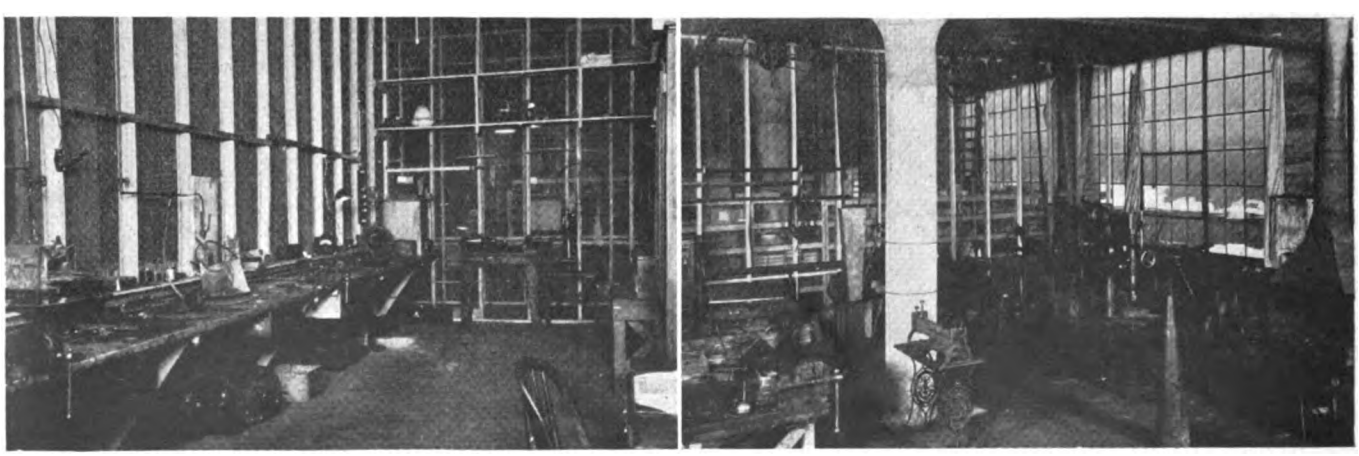
In the plants of the Corona Typewriter Company at Groton and Cortland, N. Y., the following repairs are handled by the maintenance department:

(1) All repairs to buildings and building equipment, including roofs, floors, heating and ventilating systems, plumbing systems, water system, gas system, compressed air system, sprinkler system.

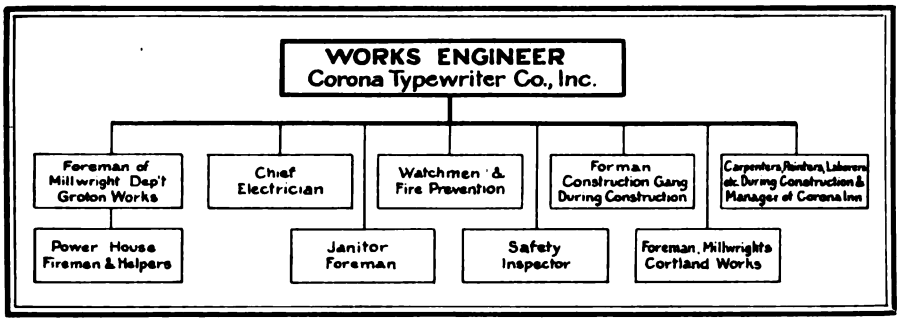
(2) All transmission equipment, such as shafting, countershafts, belting, bearings, etc.

Maintenance Shops at Groton, N. Y. Works of Corona Typewriter Company.

The photograph at the left shows the electrical shop and the one at the right, the millwrights' headquarters. These shops are adjoining.



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Organization of the maintenance department showing the divisions of the work headed by foremen.

(3) All water systems, gas, steam and compressed air systems, with the various equipment operated in connection with these systems.

(4) All electrical equipment, including motors, switches, electric ovens, electric heat-treating ovens, etc.

(5) All sheet-metal work, carpenter work and painting work.

The number of men employed varies over a wide range. This is due to the fact that it is the policy of our company to handle practically all of its own construction work of any nature whatsoever. This work has varied from the taking down and rebuilding of a 120-ft. steel stack to the complete designing and construction of a modern steel-frame, brick-veneered manufacturing building containing about 50,000 sq. ft. of floor space. During new construction such as just mentioned, the number of men employed has run as high as 160. Ordinarily, we employ but nine millwrights in the Groton works. These men have been trained so that they can handle practically any type of work which may arise. Naturally some are more expert than others and are, therefore, given a better class of work.

Two electricians handle the electrical work and we have five carpenters regularly employed in our production department, who are subject to call in case their services are required.

Our janitor department consists of a foreman and ten janitors. We also have two night watchmen and one day watchman, with two elevator operators. During the summer months, one day and one night fireman are employed, while during the heating season a helper is required during about one-half of each day.

Steam is generated for industrial and heating purposes and, during the heating season, for operating an air compressor. Our power is purchased from the New York State Gas and Electric Corporation, whose station is about 16 miles away.

At our Cortland plant, we employ a millwright foreman, who has sufficient knowledge of electricity to take care of minor repairs, while the major repairs for this plant are taken care of at our Groton works. For any major electrical construction work our chief electrician is sent to Cortland and the men at Cortland work directly under his supervision. The millwright foreman at the Cortland plant has six men, and the janitor work at the plant is taken care of by the services of two men, while a small amount of it is handled by the night watchman.

The firing of the low-pressure boilers at the Cortland plant is also taken care of by men working directly under the millwright foreman.

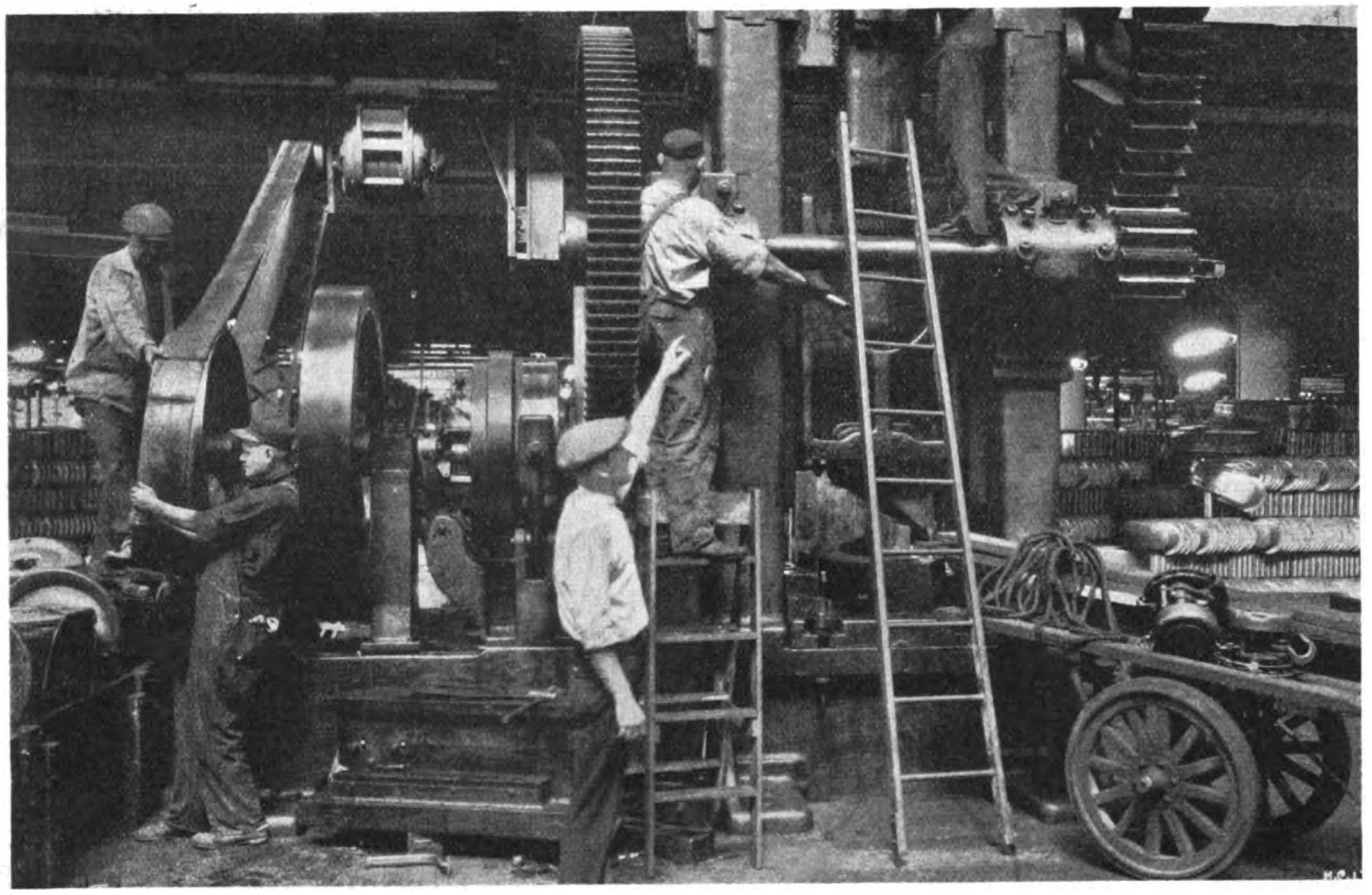
In our millwright department at Groton are a heavy-duty and light-duty drill press, tool grinder, squaring shears, rolls, crimpers, beaders and forge, while the electrician has a lathe and drill press. Any new work of great refinement is taken care of in our tool room by the tool makers.

Service is the watchword of every employee in the maintenance department and in doing their work they come across many things that are either taken care of immediately or reported back to their foreman.

(*Please turn to page 110*)



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Representative Examples of

Changes in Mechanical and Electrical Equipment

Which Have Been Made During the Past Year by Readers of Industrial Engineer, Together with the Reasons Therefor

IN PRACTICALLY all industrial plants more or less radical changes in the kind and type of equipment used are constantly taking place. There are several reasons for making such changes, although the necessity of producing goods at the highest possible efficiency in order that the resultant low costs may enable competition to be successfully met, is one of the most important reasons.

In the same manner continuity of operation, which means freedom from delays and shutdowns that inevitably cause annoying and perhaps serious losses of production, is likewise of great importance. It is often the deciding factor when alterations in equipment are contemplated or new equipment of any kind is to be selected.

Low operating and maintenance costs are considerations which frequently influence the decision of the operating man in favor of a particular type or make of equipment, or method of drive, control or operation. The desire to obtain lower operating and maintenance costs may cause him to replace existing equipment or methods with others which seem to offer worth-while advantages in these respects.

Manufacturers of industrial equipment of all kinds spend yearly large sums of money in their efforts to meet the insistent demand for equipment which will make possible greater production at lower unit costs. As a result of this study and effort new designs of equipment are constantly being brought out. The character and extent of these new developments which have been made during the past year are outlined in other leading articles in this issue of INDUSTRIAL ENGINEER.

In consequence of this continual evolution of new and better devices a good deal of equipment becomes, within a few years, more or less obsolete in the sense that later designs offer improved operating characteristics of one sort or another that make for greater all-around efficiency.

The following comments by operating men on the changes which were made during the past year in the plants under their control are representative in that they show the kind of changes that are constantly being made in industrial plants.

These comments are an index to the kind of thinking that is being done by those who have the important responsibility of keeping production going at the maximum rate by selecting equipment that is suited to the operating conditions and maintaining it at the top-notch of efficiency through the medium of well-organized inspection and repair methods that are properly and consistently carried out.

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H. D. Fisher, Plant Engineer, New Haven Pulp and Board Company, New Haven, Conn.—During the past 18 months we have installed individual motors on all jordans, driving them directly through flexible, telescopic couplings, as shown in Fig. 2, and on beaters driven in pairs by silent chains. These individual drives replaced two group drives, one driven by a Corliss engine and the other by a 400-hp. motor. The advantages sought were: To eliminate belt trouble and the resultant expense; to increase reliability of operation by confining trouble to single units; and saving of power by making it possible to shut down units which were not needed.

Smaller machines, taking up to 6-in. or 8-in. belts, which are near to each other and operate together are driven in groups to reduce the number of small motors, control equipment and wiring to be cared for. However, small machines which are somewhat isolated, and particularly those which are not in continuous use, are individually motor-driven.

We have not gone extensively into the use of ball bearings, as the heavy patterns required for our work would be very expensive and the possible savings in friction load comparatively small. Further, until our men are more familiar with the signs which these bearings give of impending trouble we fear that we would have a disproportionate number of failures. We attribute the rather excessive trouble with those which we now have to the fact that incipient trouble is not recognized and remedied before it becomes serious.

We have devoted a good deal of attention to improving our methods of handling materials, especially from vessels. Fig. 1 shows the elevated runway leading into the pulp storage shed, and a lowered part of the landing platform which is set at the height of one bale above the level of the platform of the electric lift truck, so that the first layer of bales is rolled down onto the platform, the next layer is placed directly on top of these and only the top layers have to be lifted. By the use of a double-drum hoisting engine with the load line led from the derrick boom so as to swing it in over the platform, and a guy line to a block on the vessel and back to the other drum, the hoist operator can control to a nicety the landing of the bales.

Our biggest savings have been made in coal- and ash-handling equipment. Coal is stocked by the belt conveyor equipment shown in Fig. 3, the inclined conveyor swinging on a pivot so as to cover the whole yard. Owing to its ability to dispose of coal as fast as it is unloaded, this conveyor has reduced the unloading time about 50 per cent and cut the cost about 30 per cent. A steam-jet ash conveyor has been replaced by a drag chain and bucket elevator, thereby reducing the peak load on the boilers by about 200 hp., with a considerable saving in coal. This outfit has also greatly reduced the amount of dust given off from the ashes as these can now be wet down, whereas formerly they had to be handled dry. Repair expense has likewise been reduced, as with steady use the pipe of the steam-jet conveyor, especially the portion just beyond the nozzles required frequent replacement. On the other hand, after many months of service the chains and troughs of the present equipment do not show serious wear.

The most serious problem under consideration at the present time is that of obtaining improved heat balance, increasing the amount of dryer surface so as to eliminate the necessity of using live steam in the dryers and also to reduce the number of direct steam-driven auxiliaries and increase the efficiency of those which are absolutely necessary so that there will be no excess of exhaust steam above that required for paper drying. This usually means the substitution of motors, as the development of 1 hp. in the main unit requires only about one-third of the steam that it does in the case of a small turbine running on a throttling governor.

Most changes must be pretty carefully planned in order to be sure that the expenditure will be justified and be commercially profitable. As a general proposition, I believe that the substitution of Corliss or other automatic cut-off engines for plain slide-valve, variable-speed engines; remodeling of boiler rooms with stokers adapted to burn a wide variety of coals, particularly the poorer grades; higher steam pressures with superheat; and the use of direct-drive motors with flexible couplings on all rotating apparatus, offer the best field for future progress.

* * * *

Philip C. Jones, Electrical Engineer, The Goodyear Tire and Rubber Company, Inc., Akron, Ohio.—During the past year and a half we have changed our motor specifications so as to require ball bearings on all motors under 25 hp. rating. We have been experimenting with ball bearings for six or seven years, and the step we have now taken is in line with the results of our experience.

A very high percentage of motor repairs was found to be, directly or indirectly, due to bearings. Much of the rewinding done was made necessary by rotors rubbing on the stators, due to low bearings, or to oil-soaked windings, due to careless oiling. With grease-filled ball bearings we find we elimi-

CHANGES IN PRODUCT and in manufacturing processes are of frequent occurrence in industrial works and bring about corresponding changes in the equipment used all along the paths of power service in all departments. Many other changes are the results of the necessity or desire to secure greater efficiency and reliability in the distribution of the power employed. In order to determine the character and extent of these changes in representative plants, readers of INDUSTRIAL ENGINEER were asked to tell (1) what changes were made during the past year in the equipment used in their plants, for the distribution or application of electrical or mechanical power. (2) Changes which are contemplated but have not yet been made. (3) Changes which are considered desirable, but have not been definitely planned.

In this article are given some typical reports by readers of INDUSTRIAL ENGINEER who are in active charge of plant operation and maintenance. These reports indicate clearly the thinking that is being done by operating and maintenance men.

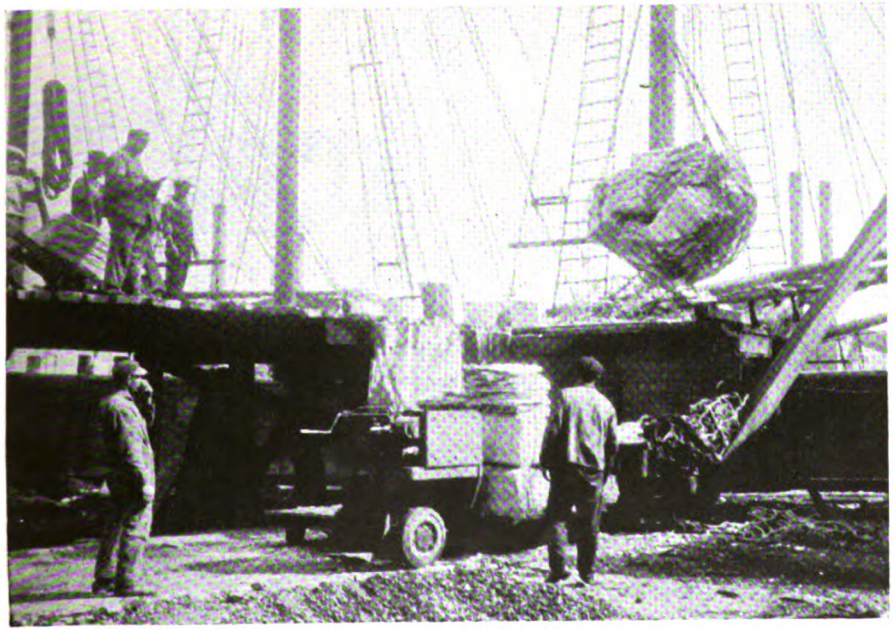


Fig. 1—The landing platform is arranged for easy handling of the raw material by electric truck.

The raw material is delivered in the form of bales by boat onto a landing platform, part of which is lowered to the height of a bale on the platform of the electric truck, by which it is taken to storage. The first layer of bales can thus be rolled directly onto the platform of the truck, the next layer is placed on top of these and only the top layers have to be lifted.

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nate a lot of this trouble as well as diminish our oiling expense.

We have made no radical changes in types of motors or controls. The tendency is toward a greater use of d.c. motors. With the increasing use of individual drive and machine operation, speed adjustment becomes increasingly desirable which, at the present time, means the use of dc. motors.

We generate all our energy and do not contemplate doing otherwise. In a plant our size, with a peak load of 30,000 kw. and a 60 per cent load factor, where considerable quantities of steam are used for manufacturing purposes, it is very difficult for a central station to offer to supply energy at a price which would seem attractive.

During the past year we inaugurated the practice of passing all new major equipment, such as motors and transformers, through the Electrical Laboratory for test before taking them into the plant. This has proven well worth while already.

In the way of lighting equipment I can record the tendency toward higher intensities, and also toward the use of daylight lamps. This last is of particular interest. We have found that we can replace a 100-watt type C lamp with a 100-watt C-2 (daylight) lamp and get better results in spite of the absorption in the C-2 globes.

We are working toward increasing standardization and simplification of all electrical work, but changes which we have made or contemplate along this line would require more explanation than space now permits.

* * * *

E. D. Chrisman, Chief Electrician, Lynchburg Foundry Company, Lynchburg, Va.—During the past year, a great many changes have been made in our plant in order that production could be increased, and the high standard of our good products be maintained.

Small three-phase auto starters with pushbutton control have been installed on saws and other small equipment driven by motors up to, and including, 5 hp. rating.

Bandsaws have been motorized in order to do away with long belt drives and countershafts.

Motor-driven saw filers and tool grinders have been installed in the pattern shop in order to do away with hand work. Small portable motor-driven grinders and buffers have been installed in the metal pattern department, doing away with all hand work, such as filing and sanding.

A new motor-driven cinder mill has been put in operation for reclaiming coke and iron from the cupolas of the pipe shop, special foundry, and the plow foundry.

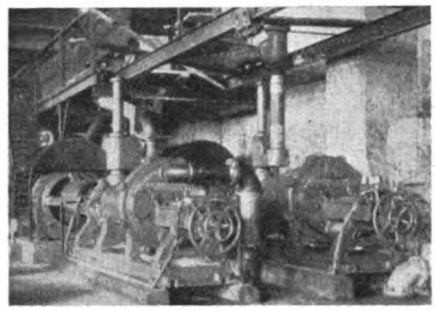


Fig. 2—Jordon engines have been changed to individual drive through flexible, telescopic couplings.

The jordans, as well as the beaters, were formerly group-driven, a Corliss engine and a 400-hp. motor supplying the power for two main group drives. The beaters are now driven in pairs through silent chains.

In the pipe shop we have changed the motor on the trolley of No. 1 crane, from 6 hp. to 10 hp. in order to change the cycle of operation from throwing the flask with the bridge motor to the trolley motion on the shake-out bars.

In the core department, we have placed in operation two Shepard, I-beam, 3,000-lb. hoists, with hook speeds of 80 and 60 ft. per min. at full load. The hoist motor is a 10-hp., series, interpole motor with series brake and the travel is a 2¼-hp. Zabell series, interpole motor with series brake. Both motors are controlled through Shepard pulpit-type controllers working through G. E. protective panels and automatic overload contactors.

In the special foundry, we have installed two Shepard 3-ton, floor-controlled, double-beam cranes, with hook speeds of 40 to 80 ft. per min., full load. The hoist motor is a Crocker-Wheeler, 6-hp. series motor, and the bridge is a 3½-hp. Zabell series motor, both having series brakes. The trolley motion is hand-controlled, and the other two motions are controlled from the floor with Shepard rope-type controllers, which are mounted on the hoist frame.

Plans have been prepared by our plant superintendent, and work has started on the addition to the power house that is to be built in order that we may have greater capacity on the d.c. side of the system.

We are adding another synchronous motor-generator set identical with our other two sets. This machine is to be paralleled on the bars when necessary, and operated independently when the load is light enough for one machine to carry it. The synchronous motor is a G. E., ATI-6, 160-kva., 2,300-volt machine, and will be directly connected to a G. E. MPC, 115-kw., 250-volt d.c. generator, with the excitation circuit taken from the generator end. The machine will be controlled from a panel placed beside it on the main floor, the same as for the other machines, and equipped with auto starter, overload and no-voltage relays, and over-speed trip circuit breaker in series with the auto starter circuit.

The addition to the d.c. board on the mezzanine floor of the power house will contain a panel with all necessary instruments, circuit breakers, equalizing switches, and ground detectors. Another panel will consist of a voltage regulator, motor-driven, and a stabilator in parallel with the d.c. bus. All the wiring from the main board and panel boards to the machine will be in conduit under the floor. The incoming high-tension lines will be equipped with disconnects and oil breakers, with a separate breaker for each machine in the power house, including the 2-stage air compressors driven by 2,300-volt, 17-hp. motors.

We are contemplating changing some

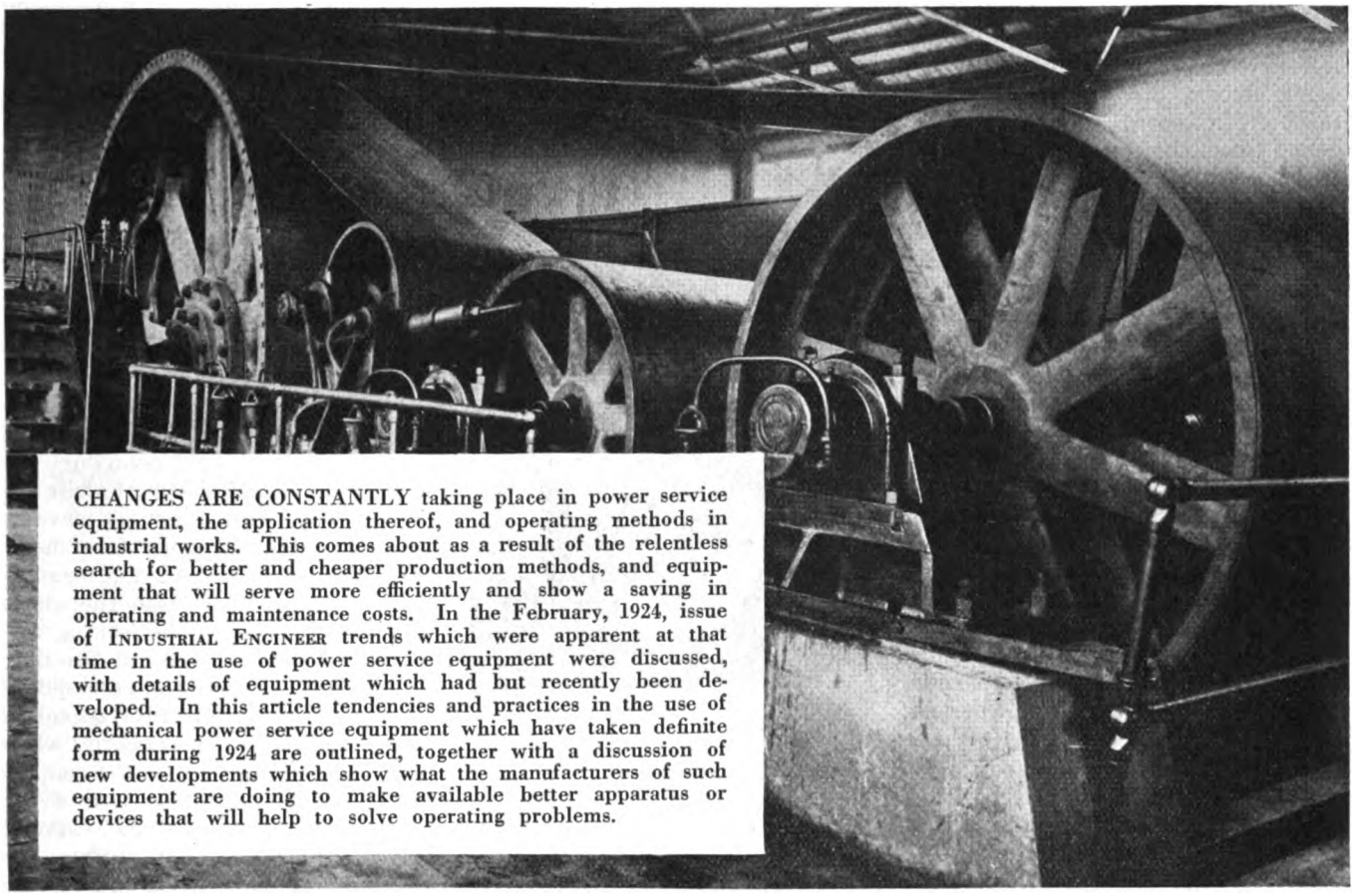
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Fig. 3—The use of efficient coal- and ash-handling equipment has resulted in large savings.

The installation of a belt conveyor reduced the cost of handling coal 30 per cent, with a 50 per cent reduction in the time required. Similarly, the replacement of a steam-jet ash conveyor by a drag chain and bucket elevator took a heavy load off the boilers and reduced maintenance costs.

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CHANGES ARE CONSTANTLY taking place in power service equipment, the application thereof, and operating methods in industrial works. This comes about as a result of the relentless search for better and cheaper production methods, and equipment that will serve more efficiently and show a saving in operating and maintenance costs. In the February, 1924, issue of INDUSTRIAL ENGINEER trends which were apparent at that time in the use of power service equipment were discussed, with details of equipment which had but recently been developed. In this article tendencies and practices in the use of mechanical power service equipment which have taken definite form during 1924 are outlined, together with a discussion of new developments which show what the manufacturers of such equipment are doing to make available better apparatus or devices that will help to solve operating problems.

This shows two leather belts on a Morgan mill driving the finishing stands of a strip mill in a large steel plant. The inner belt receives unusually hard service because of the severe flexing to which it is subjected. On this drive the load fluctuates from zero to maximum within 30 seconds. Acknowledgment is made to Chicago Belting Co., Chicago, Ill., for this illustration.

Trends and New Practices in the Use of

Mechanical Equipment in the Path of Power Service

In Industrial Works, Together With Details of Recent Developments Which Are of Interest to Users of Such Equipment

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer

CURRENT practice in the design of power service equipment and changes in its application show, year after year, definite trends and tendencies which are the results of study of both the manufacturers and the users of such equipment. These developments and the changes which they bring about are definite steps in a never-ending search for designs which will give increased operating efficiency, greater reliability in operation and a reduction in operating costs, and for methods of application that will further the attainment of these ends.

During the past year some new trends of practice have become apparent, while other tendencies which were previously more or less well defined have gained added impetus.

For example, in line with the general increase in the working speeds of production machines, the use of higher lineshaft speeds, which now frequently range from 300 to 400 r.p.m., is very noticeable. Increasing use of ball and roller bearings on line- and countershafts follows closely the adoption of these comparatively high speeds. Belt speeds are likewise being increased, while there is a strong tendency to use smaller pulleys than were formerly employed.

The question of the comparative merits of group and individual drives is always an interesting one. Users of production tools are realizing more and more that neither group nor individual drive is a cure-all for every operating trouble, but that each type of drive has its legitimate place where it can function to better advantage and probably more efficiently than the other. General practice now seems to be to use individual drive whenever it is possible or advisable to do so when machines are operated as separate units. In fact most builders of large machine tools and similar equipment now make provision for mounting a motor directly on the machine, in case it is desired to do this.

Increasing use of individual drive has led to a wide employment of speed reducers as the logical solution of the problem which is presented when it is desired to connect a comparatively high-speed motor

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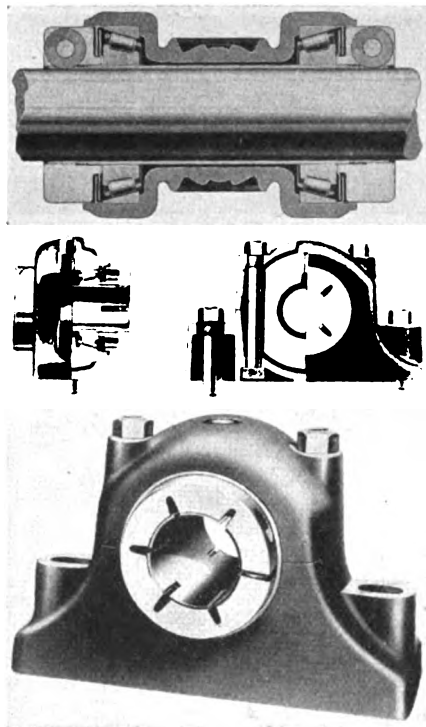
directly to the slower-moving shaft of the production machine. In a few new installations lineshafts are being driven directly by a motor through a speed reduction unit which turns the lineshaft at the desired speed.

In similar fashion, the use of silent chains for both group and individual drives is being applied to new applications. In the case of group drives the chain may be used between the motor and the lineshaft in places where the distance between these is not sufficient to permit the advantageous use of belting. Also, chains are being used to transmit power between two closely adjacent lineshafts and between lineshafts and countershafts. In individual drives, chains are used to couple the motor shaft to the machine shaft, usually with a reduction in speed. In many such instances the distance between shafts is too short to permit the satisfactory use of belts, whereas this condition is no bar to the use of chains, which give the additional advantage of a positive drive. Along the same line belt manufacturers have shown a marked activity in the study of better belt applications and the economies that result in maintaining and reclaiming belts so as to extend their life and increase the efficiency of belt drives. These tendencies have been reported in INDUSTRIAL ENGINEER in serial articles during 1924.

In the following pages a description is given of new developments in the leading items of equipment, which have made possible some of the above-mentioned practices, or have been brought out as a result of them.

Ball, Roller and Sleeve Bearings

The problem of reducing friction in bearings as much as possible has always occupied a good deal of attention on the part of manufacturers and users of power equipment. Friction and power losses are inevitable in any bearing, but they can be kept down to a minimum by the use of properly-designed bearings which are suited to the service conditions. The problem of lubrication from the standpoints of attention required in operation and troubles involving maintenance and repairs is also receiving much attention by both users and manufacturers.



The Dodge-Timken roller-bearing shaft hanger and pillow block.

The upper illustration shows a sectional view of the Timken tapered-roller, shaft hanger bearing. The middle and lower views show the construction of the roller-bearing pillow block and the complete assembly, respectively.

One development of interest which has taken place during the past year is the standardization of ball bearing sizes for industrial motor applications. The need of making the application of ball bearings to general-purpose motors the simplest possible stock proposition has been recognized for some time and the leading manufacturers of these bearings have given this point the most carefuly consideration. Practically every American make of motor was studied and the data thus obtained turned over to a committee of ball bearing engineers who had made a special study of electric motor requirements. The recommendations of this committee were drawn up in the form of a report which was subscribed to by the co-operating companies.

These engineering standards apply only to horizontal, general-purpose electric motors having present Electric Power Club pulley diameters, belt widths, shaft extension diameters, and pulley overhang ratios lying within certain values. The ball bearing sizes recommended by the manufacturers for use in general-purpose motors, together with a more complete account of the work done in this connection, were given on page 503 of the October, 1924, issue of INDUSTRIAL ENGINEER.

Among the recent improvements in ball and roller bearings, mention may be made of the so-called self-locking collar which has been applied by The Fafnir Bearing Company, New Britain, Conn., to the bearings used in their ball-bearing hanger boxes, pillow blocks and other industrial applications. In any ball-bearing application it is necessary to have the inner race member rotate as an integral unit with the shaft. It is, therefore, necessary to make some provision for securing the inner race to the shaft. Fafnir industrial-type ball bearings have a wide or extended inner race member. The outer end of this member is machined eccentric to the shaft on which it turns. The locking collar which serves to locate the unit on the shaft has one end recessed or counter-bored and is also eccentric to its true bore. Consequently, when this collar is applied to the end of the inner ring, any tendency of the latter to creep on the shaft simply serves, it is claimed, to tighten or lock the ring on the shaft. The collar is securely fastened to the shaft by one or more setscrews.

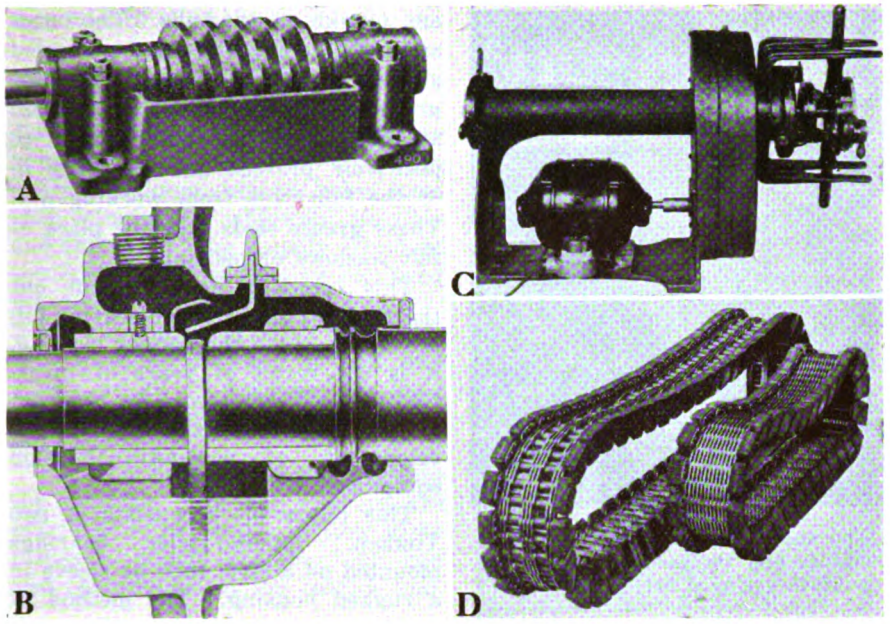
Standard Steel and Bearings, Inc., Plainville, Conn., has brought out a ball bearing intended primarily for use in the clutch pilot of automobiles, but which it is claimed can be used on any application where the bearing is located in a place that is inaccessible for lubrication, and thus difficult or impossible to oil without disassembling the mechanism.

The novel feature of the bearing is a retainer of sheet steel that is expanded into a groove cut in the outer ring for that purpose. The retainer is made in the usual manner, and when completed is of a diameter that allows it to be dropped into the bearing. A press operation then enlarges the diameter by direct pressure upon the convexed surface so that it cannot be displaced except by driving.

When the mechanism in which the bearing is used is assembled, the latter is packed with suitable grease and so placed that the open side is toward the blank end of the recess. In this position the retainer holds the grease in the bearing.

Chandler Machine Company, Ayer, Mass., has put on the market a roller bearing for use on lineshafts, which consists of a cast-iron housing enclosing two load collars

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New developments made during 1924 that cover a wide range of industrial equipment.

At *A* is shown the worm gear box brought out by the W. A. Jones Foundry and Machine Co., for installations in which the use of an enclosed worm gear reduction is not justified. *B*, sealed sleeve bearing for industrial motors, developed by Westinghouse Electric & Manufacturing Co. *C*, pipe cutting and threading machine put out by Oster Manufacturing Co. This machine is driven by a ⅓-hp. electric motor and will handle pipe up to 2 in. in diameter. *D*, new steel-link, V-belt designed by Reeves Pulley Co., for use on Reeves variable-speed transmissions.

within which the rolls revolve. The bottom of the housing is fitted with two copper oil wipers, one at each end, to prevent the oil drifting along the shaft and out of the bearing.

The load collars, which are split for ease in installation or removal, and held together with strong screws are, it is claimed, made of a special tough metal and are of ample width to carry a heavy load. These load collars have a groove in the middle for housing split, steel spacing rings which keep the rolls in their respective places.

The rolls are said to be made of a special grade of tough, tool steel, finished true to size and cut short enough to leave plenty of room for free running between the shoulders of the load collars. Both ends of the rolls are finished in circular form, so that they act as balls when they touch the shoulders of the load collars.

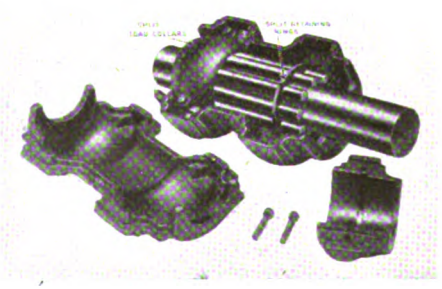
A line of disk and ball bearings designated as the NKA and for which high load-carrying capacity is claimed has been placed on the market by the Wollmar Engineering Corporation, 224 East Forty-second Street, New York, which is the American representative of Nordiska Kullager Aktiebolaget, Gothenburg, Sweden.

The disk bearing is made up of two race rings, between which rollers having convex race surfaces and flat side surfaces are placed. A feature of the bearing is that the rollers are claimed to be self-guiding.

A feature of the NKA ball bearing, which is available in both radial and thrust types, is the ball cage or separator. This cage is made of spring steel wire, which is looped between each pair of balls, embracing a segment of each ball. This construction is emphasized as minimizing friction, taking up little space, and permitting lubricant to get in between the balls. The balls may be inspected without taking the bearings apart. The ball race grooves are deep and close fit of the balls is intended to provide greater carrying capacity. The method of introducing the balls between the race rings is featured as permitting a large number of balls to be inserted into the bearing.

Details of the Chandler Machine Co.'s roller bearing.

Below, bearing with the upper half of the housing and upper half of one of the load collars removed to show the rolls and one of the roll-retaining rings. The upper view at the right shows the rolls in place in the load collars, ready for assembly in the housing. Lower right, bearing completely assembled except for upper half of housing.



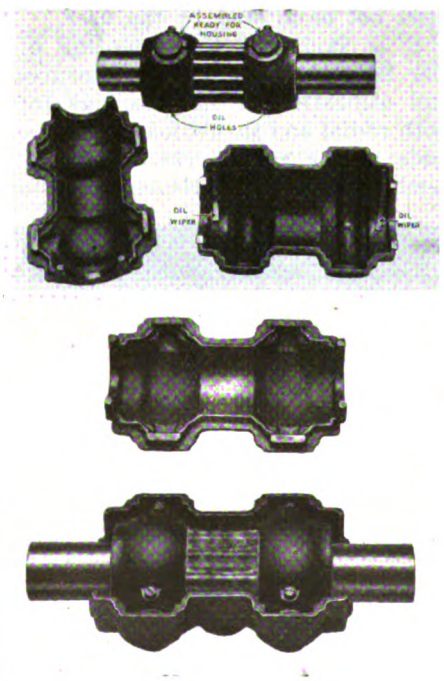
Under the trade name "Excello," the Ex-Cell-O Tool & Manufacturing Co., Detroit, Mich., is now marketing a high-speed ball bearing, licensed under the Snader patent application. This bearing is of the combined radial and thrust type and is designed for speeds up to 50,000 r.p.m.

The ball races are so located in relation to each other that it is claimed the balls are given a spinning motion in addition to the motion of rolling around the center of the shaft. This construction is for the purpose of eliminating the wearing of flat spots or tracks on the balls.

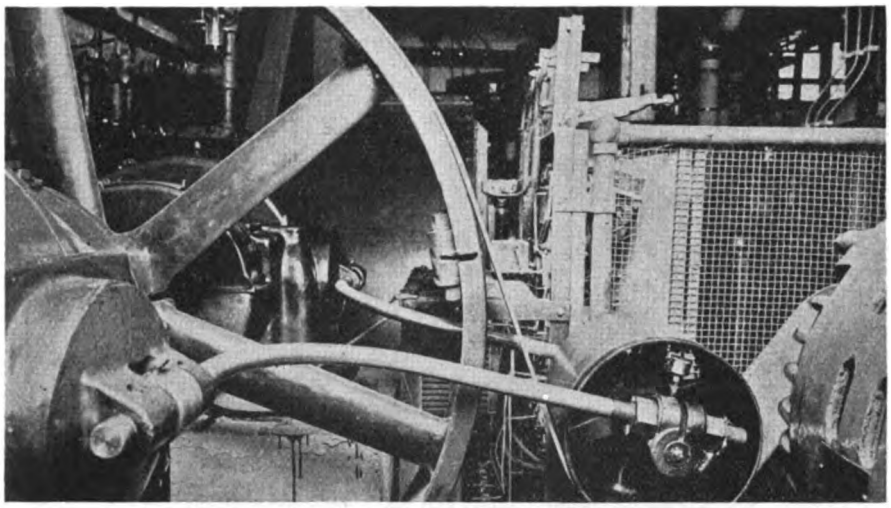
Since the outer races are at an angle, a worn bearing can be salvaged by grinding the inside faces of the outer rings. If the surfaces of the races are excessively pitted or worn, these surfaces can be reground. Bakelite ball separators are used.

Marlin-Rockwell Corporation, successor to Gurney Ball Bearing Company, Jamestown, N. Y., has during the past year further developed and made some additions to its line of Conrad deep-groove ball bearings. They claim that these bearings are particularly suited for high-speed installations and also for applications where the loads are comparatively small but the bearings are likely to be subjected to thrust loads from both directions.

The Dodge Manufacturing Cor-



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The short distance between pulley centers and the service conditions make this a hard drive.

This belt drives an air compressor which is fitted with an automatic pressure regulator that starts the motor when the pressure falls to a certain point and stops it when the pressure reaches the upper limit. The motor starts up at about 5-min. intervals and runs for 2 or 3 min. By courtesy of The Graton and Knight Mfg. Co.

poration, Mishawaka, Ind., has placed on the market a new lineshaft bearing embodying the Timken tapered-roller bearing, as well as several new features of construction.

The Timken tapered-roller bearing is constructed on the cone principle which, it is claimed, insures a true rolling action. The bearing itself comprises four parts: a cone or inner race with outside taper, the tapered rollers, a cage or roll retainer and a cup or outer race with inside taper.

The Dodge-Timken roller hanger bearing is a simple bearing. It consists of two Timken, tapered-roller bearings mounted on a ground and slotted steel tube and fitted to an accurately machined housing. The ends of the steel tube are threaded to receive clamping collars designed to secure accurate adjustment of the bearings on the tube. This adjustment is made at the factory and need not be altered by the user.

It is said that the mounting of the tapered-roller bearings insures full utilization of the bearings for both radial and thrust loads. It also adds to the ruggedness of the assembly and is of particular value in resisting the side weave of heavy driving belts.

The method of fastening the steel tube or sleeve to the shaft permits its use on any commercial shafting, by setting up the screws in each of the two clamping collars.

The dust-proof design of this bearing is featured as being of great importance. The sleeve on which the bearings are mounted extends from end to end of the housing. Liberal grease compartments are provided inside of the housing and outside of the tube. The outer ends of the bearings are protected against dust by special metallic grease seals which eliminate friction at this point and are claimed to positively prevent dust working in or the lubricant from working out. These grease seals take the place of felt washers or packing.

This company has also put out the Dodge-Timken roller-bearing pillow block. Like the hanger bearing, it is the result of years of investigation and experience on the part of the Dodge organization in the development of power-transmission equipment.

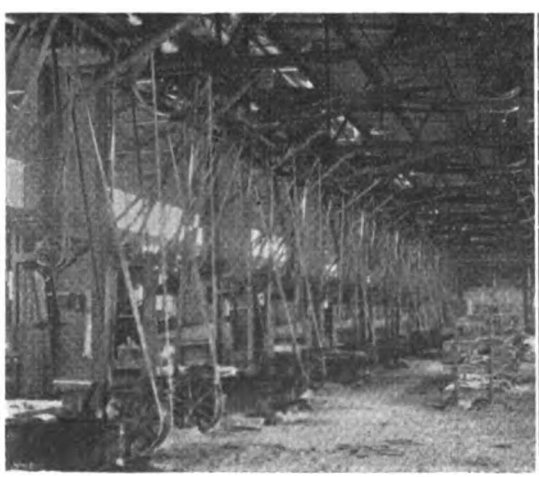
This pillow block consists of two Timken, tapered-roller bearings mounted on a steel tube or sleeve in a rugged housing. The method of fastening the steel sleeve to the shaft permits its use on any commercial shafting by setting up the screws in each of the clamping collars.

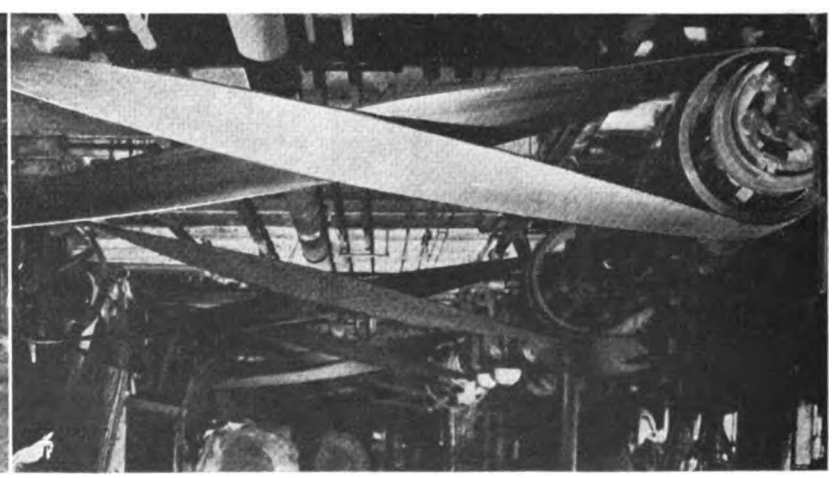
The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has developed a sealed sleeve bearing for industrial motors.

The new bearing is so constructed that the housing is practically air tight, preventing air from getting in and oil from leaking out. The bearing shell itself has not been changed in design but the housing has been altered. The cover which closes the opening through which the oil ring is admitted has been placed on the inside end of the housing instead of the outside. This location permits bolting down the cover and compressing the packing under it. For the purpose of inspecting the oil ring, a large pipe plug has been placed on the outside end of the housing. This plug can easily be removed and put back in place, air-tight. The dowel pin, which is ordinarily inserted from the out-

Two installations where the belts operate under extreme conditions.

The illustration at the left shows leather belts driving stone planers in a quarry. The loads are heavy and service conditions severe. The belts shown at the right are operating in a tannery where excessive moisture makes the operating conditions still more severe. These illustrations are used by courtesy of Chicago Belting Co.



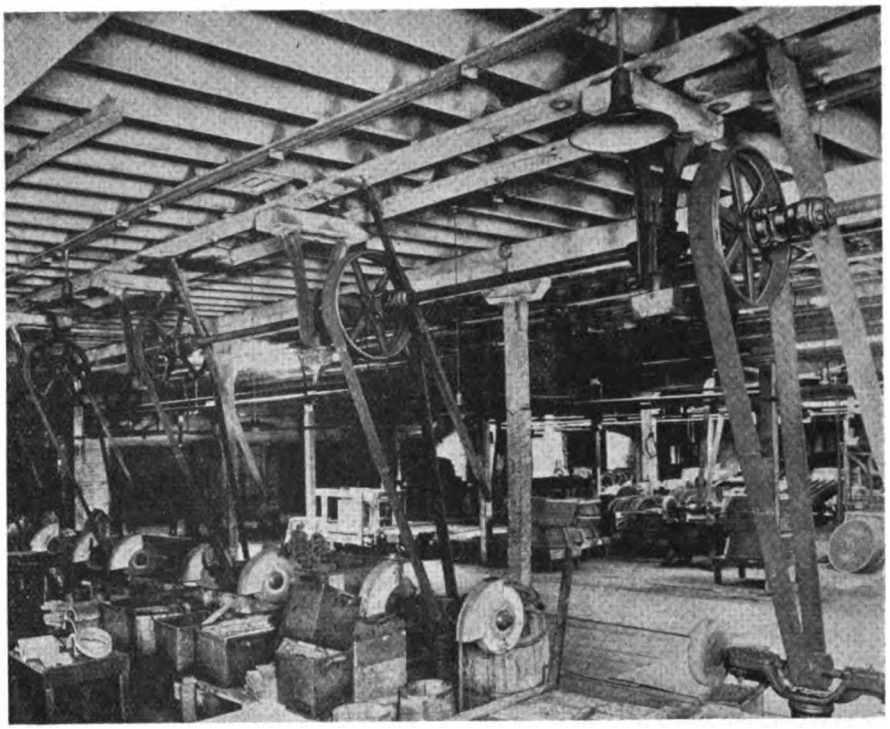


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side wall of the housing to keep the bearing from turning, has been placed on the inside of the housing and any oil pumping is thus rendered harmless since it is inside the housing itself. To further guard against leakage, tapped holes have been eliminated wherever possible and the drain plug usually found at the bottom of the housing has been removed.

To eliminate throwing of oil, a conical collar forming a seal and acting as an oil thrower has been placed on the shaft on the inside of the bearing.

For the purpose of dustproofing the housing, soft felt washers are placed at either end. In very dirty places a double chamber cap can also be provided at the outside end.



This row of grinding machines is driven directly from the lineshaft through clutch pulleys made by the Conway Clutch Co.

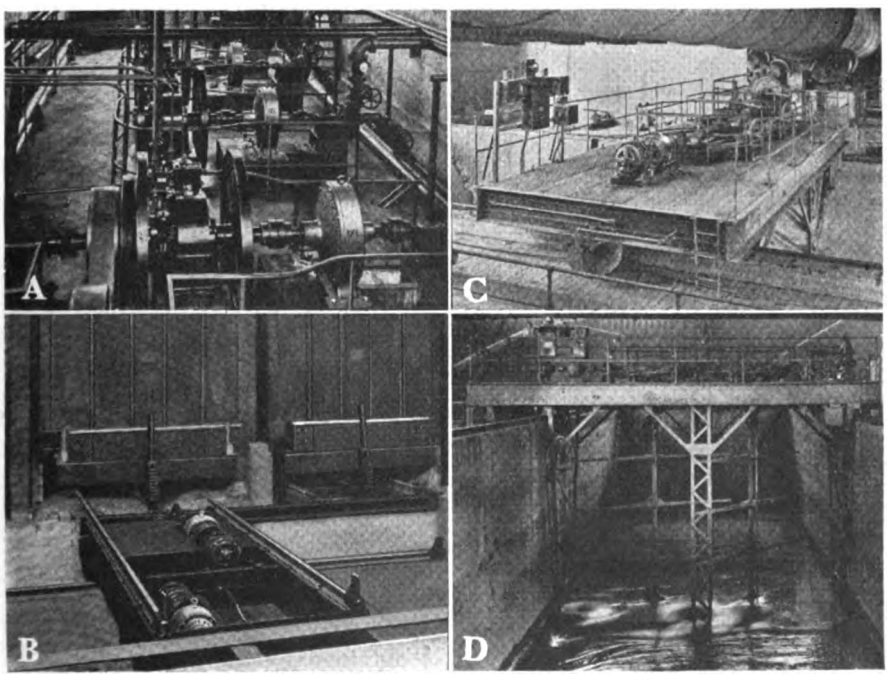
Belting and Pulleys

The Leather Belting Exchange, which is an association of leather belting manufacturers, has for some time carried on practical research work covering the problems involved in the manufacture and application of this equipment. A non-technical summary of some of this research work, which has been done under the direction of R. F. Jones, has recently been published by The Leather Belting Exchange. This report contains the results of studies made on such subjects as: arc of contact studies; effect of center distance on transmitting capacity; the effect on the belt's capacity of using a small pulley to drive a large one, and *vice versa*; and so on.

This report is well illustrated with curves and charts and contains a large amount of very valuable information, much of it in tabular form.

Alexander Brothers, Inc., Philadelphia, Pa., are marketing under the name "Tentacular," a suction belting which is made up of oak-tanned leather to the under surface of which are attached narrow, longitudinal strips of soft and spongy, chrome-tanned leather. The strips of chrome leather are held in position by hollow brass rivets. The depressions, or hemispherical pockets in the strip, having the inside of the hollow rivet as bottom, are intended to act as suckers and cause the adhesion of the belt on the pulley. The adhesion of the belt is also increased to a large extent by the spongy chrome leather, which is treated with tallow. The spacing between the strips is intended to permit any air film between the belt and pulley to be squeezed out. Shifting from fast to loose pulleys is effected as with the usual leather belting and because this belting can be run at lower tension, stretching of the belt is said to be less than usual.

The thickness of the chrome



Interesting applications of IXL reducers.

In *A* is shown a battery of rotary pumps driven through speed reducers, which are reversed, (low-speed shaft connected to the driving engine) to increase the speed of the pumps. *B*, transfer table for electric annealing furnaces. The motor and speed reducer at the back drive a small pinion which engages with a rack, the outer end of which is hinged and shown here pushed back against the door of the furnace. The rack serves to pull the loaded cars from the furnace onto the transfer table. The motor and speed reducer at the front of the table drive the latter along the track when cars are put into or removed from the furnaces. *C*, movable platform which carries revolving paddles for agitating the contents of a long slurry tank in a cement mill. The platform travels on a track along the edge of the slurry tank at a speed of 935 ft. per hr. *D*, another view of the traveling platform showing the agitating paddles which are driven by a 10-hp. motor through a speed reducer. These illustrations are used by courtesy of Foote Bros. Gear & Machine Co., Chicago, Ill

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leather strips is 1/8 in., although thicker strips may be employed. The strips are either 3/4 or 1 in. wide. The dressing used is tallow, which is melted and spread over the chrome strips with a brush. This dressing is applied two or more times a year, depending on the drive; as a rule, the tallow dressing is required when the strips become dry or a slight slippage occurs.

The use of this belting is claimed to eliminate slippage, high belt tension, high pressure on bearings, and the use of belt dressings. Considerably more power is said to be transmitted for the same width of belt.

The Graton and Knight Manufacturing Co., Worcester, Mass., report that tanning and other manufacturing processes have been thoroughly standardized in its plants and that a large amount of work is being done on the standardization of the types of belting particularly adapted for the various machines used in the different industries. This work involves the installation and careful study of test belts, over a period of time, so that by a process of elimination the size and type of belt best suited to the conditions is found.

Belt maintenance and reclamation work is a subject that has for some years past attracted a good deal of attention. This has come about largely as a result of the increasing severity of the service to which belting is subjected by reason of the tendency to increase belt and line-shaft speeds, with a realization on the part of belt users that belting must be kept in the proper condition if it is to deliver the maximum service of which it is capable.

Under the trade name "Renovatol," Renovatol Company, Philadelphia, Pa., is marketing a material which may be applied to belts while they are running at full speed and under full load for the purpose of cleaning and degreasing them, and leaving them soft and pliable. It is claimed that this material will remove water and dampness from belts while they are running and make them waterproof and that, by giving them a velvety, friction surface, it permits belts to be run at a very low tension. This material is intended for use only on leather and canvas belts.

The Clipper Belt Lacer Company, Grand Rapids, Mich., has recently placed on the market a new model known as the Baby or No. 0 Clipper Belt Lacer, which embodies a number of improvements. It will lace any belt up to 3/8 in. thick and 4 in. wide in one operation. For wider belts it is merely necessary to repeat the operation. A vise is used in connection with this tool.

Clipper Rustproof Hooks have recently been brought out by the same company for use in laundries, mines and other places where there is excessive moisture and ordinary hooks show corrosion.

One feature of a new line of paper pulleys, recently placed on the market by the Best Pulley Mfg. Co., St. Louis, Mo., is the use of a patented, double-locking hub which has three sets of ribs each which grip into the paper and prevent the hub from coming loose, even though the pulley may be reversed in direction. These ribs are a part of the hub and extend out from the hub in a V-shape so that when the hub is hydraulically pressed into the pulley it becomes an integral part thereof.

In making these pulleys, treated paper is hydraulically compressed into a solid block. The end grain of the fiber is exposed to the belt so that belt slippage will be reduced.

It is stated that the pulleys are to be built in 2,500 stock sizes.

Speed Reducers

The De Laval Steam Turbine Co., Trenton, N. J., has developed a line of worm gear reductions which are applicable to motors and turbines driving such machinery as rotary kilns and coolers, tumbling barrels, agitators, mills, paper machinery, machine tools, stokers, cooling tables, transfer rolls, elevators, conveyors and so on. It is claimed that in the De Laval worm gear, three or more teeth are always in contact, giving exceptionally high load capacity for the size and weight, and making the gear suitable for heavy-duty service.

The reduction is completely enclosed in a casing, which keeps out dust and moisture. The casing is split horizontally in the plane of the center line of the wheel shaft, and the lower half is supported by four substantial feet designed to permit air circulation underneath.

The wheel shaft is carried on plain bronze bearings, so split as to be easily removable without disturbing the wheel shaft or the couplings. The side thrust of the wheel is carried by a hardened, ground and polished steel plate.

The worm may be located either above or below the wheel and is mounted on ball bearings, the one at the rear of the worm being of the double type and designed to carry the combined radial and thrust loads. The bearing at the forward end of the worm is of the radial type; the inner race is pressed on the worm shaft, while the outer race has clearance axially, permitting the bearing to adjust itself to the linear expansion of the shaft.

De Laval worm reduction gears are made for transmission ratios of approximately 4 to 1 up to 100 to 1 in one step, and for any higher ratio with double reductions. Flexible couplings of the pin and rubber bushing type are used to connect the worm shaft to the driving machine and the wheel shaft to the driven machine.

The Hill Clutch Machine & Foundry Company, Cleveland, Ohio has developed the "Industrial Type" spur gear speed transformer for all general industrial work where speed transformer units are operated under continuous or heavy service conditions. This speed transformer consists of a nest of plain spur gears revolving in oil. Both high- and low-speed shafts are supported in double bronze bearings, insuring, it is claimed, strength, rigidity and quiet operation.

A splash system of lubrication, obtained by a metal disc on the high-speed shaft, is used. The entire unit is enclosed and is claimed to be dustproof and leakproof.

Both high-and low-speed shafts are in identical axial alignment and both revolve in the same direction.

The Poole Engineering & Machine Company, Baltimore, Md., has recently brought out two new types of reduction gears known as type H and type K, respectively.

The type H reduction gear consists of a herringbone gear and a herringbone pinion cut integral with the high-speed shaft. Both gear members are said to be made of special steels and heat-treated.

The gears and pinions are totally enclosed in a cast-iron, horizontally-split casing with bearing bosses integral with the top and bottom halves of the casing. The bearings are removable and consist of cast-iron shells lined with babbitt metal. They are supported in bosses cast in the top and bottom halves of the casing.

For low-speed drives lubrication is obtained by an improved splash

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and gravity system. For turbine and other high-speed drives an oil pump and cooler are provided.

The type K reduction gear consists of a herringbone, forged-steel pinion integral with the shaft and a cast-steel herringbone spur gear. The gear and pinion shafts are mounted in babbitted bearings of the ring-oiling type and are lubricated by the splash system.

A recent addition to the line of worm-gear reduction units manufactured by the Cleveland Worm & Gear Co., Cleveland, Ohio, consists of a small unit to transmit loads up to 3 hp. It is available in ratios varying from 5 to 1 to 30 to 1.

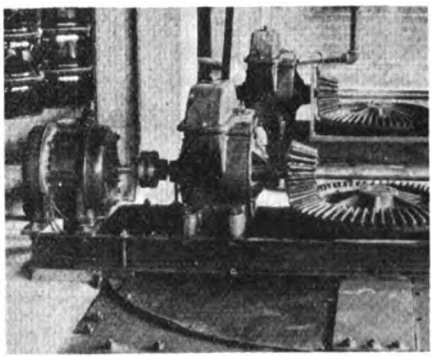
The worm is located above the wormwheel and is mounted on ball bearings of a combined radial and thrust type, designed to take a thrust load in either direction. The thrust and radial loads from the wormwheel shaft are taken by the Timken tapered-roller bearings on which this shaft is mounted.

The case is of cast iron and has sufficient volume to accommodate an ample supply of lubricating oil. The wheel bearings are lubricated by the splash from the gearing, the contacting surfaces of the worm and wormwheel as well as the worm bearings being lubricated by the oil carried up from the reservoir by the wormwheel as it revolves.

The Meachem Gear Corp., Syracuse, N. Y., has recently taken over the manufacture of a speed-reducing mechanism for the transmission of power from high-speed turbines or motors to machinery that must be driven at a lower speed.

In this reducer the load is transmitted from the high-speed shaft through planetary gears to a slower rotating ring. A number of rockers are connected inside the ring and engage a spider keyed to the low-speed shaft. As the driving motor or turbine starts up, the engagement of the rockers with the spider causes each rocker to compress a spring plunger. This action brings the bottom of the rocker into positive contact with the inside of the ring, and, at the same time, causes the side of the rocker to make contact with the side of the adjacent spider tooth.

The load on the turbine or motor is reduced to practically nothing during the time required to compress the springs, this period of time corresponding to about one-quarter of a revolution. The load is, therefore, said to be transmitted



These agitators are driven by 10-hp. motors through 9.86-to-1 ratio. Industrial Type speed reducers made by The Hill Clutch Machine & Foundry Co.

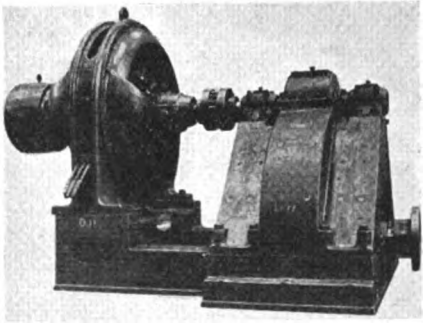
gradually and without starting shock. The spring plungers also aid in the maintenance of quiet operation, since they tend to eliminate vibration and backlash.

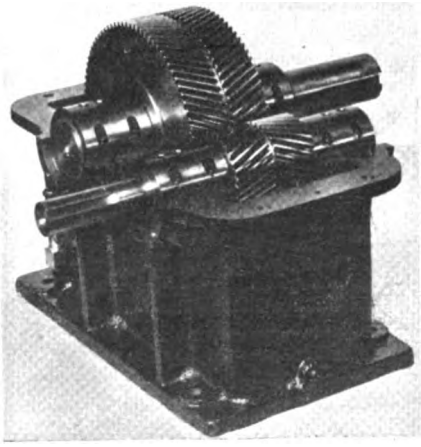
The shafts are mounted on ball bearings which are housed in substantial casings and have ample provision for lubrication.

The mechanism is entirely inclosed in a dustproof casing, and all parts run in oil, with forced lubrication above 1,800 r.p.m. The reducer can be used for either step-up or step-down speed changes. It is furnished in ratios from 4 to 1 up to 200 to 1, and for loads up to 500 hp.

Herringbone gears are used in the new speed reducer brought out by the Poole Engineering and Machine Co.

The type K reducer, in which the pinion or high-speed shaft is on top, is shown in the upper illustration. The lower view shows the type H reducer with the top casing removed.





Foote Bros. Gear and Machine Co., Chicago, Ill., report that several novel and interesting applications of IXL speed reducers have been made during the past year. For example, in an installation at the plant of the Western Machinery Mfg. Co., Sedalia, Mo., a number of these speed reducers are used to increase the speed of a battery of rotary pumps.

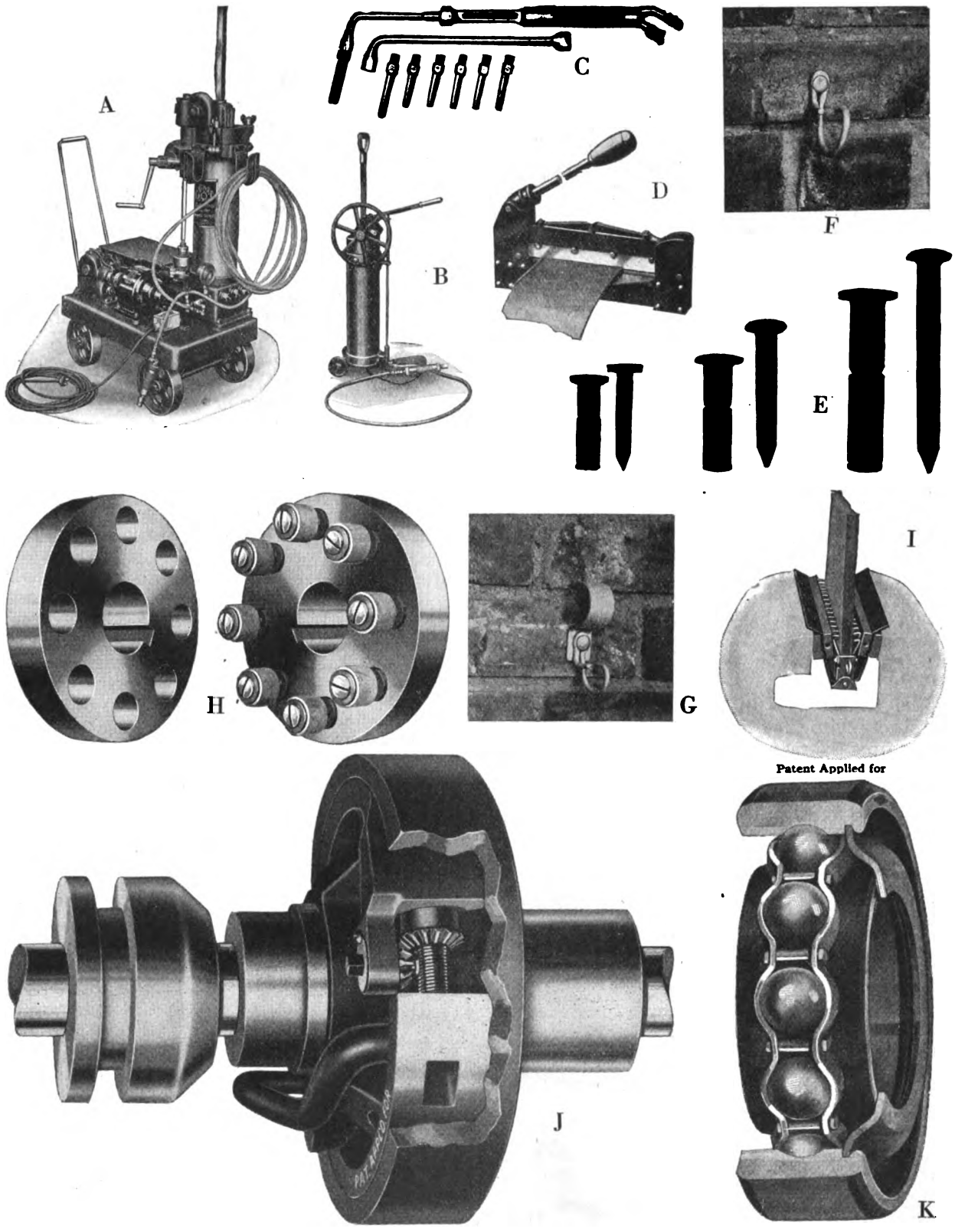
What is said to be another new application of IXL speed reducers is in the plant of the Glens Falls Portland Cement Co., Glens Falls, N. Y., where a change in manufacturing processes made necessary the installation of a slurry storage tank 125 ft. long, 25 ft. wide and 21 ft. deep. Owing to the size of the tank it was considered impracticable to use the standard form of stationary paddle mixers, and a traveling agitator with rotating paddles was installed.

Briefly, the agitator consists of a platform built on a structural steel frame and equipped with wheels which run on tracks on the edge of the tank or pit. It requires 7½ min. for the platform to travel from one end of the tank to the other. Power for running the agitator arms is supplied by a 10-hp., 570-r.p.m., G. E. motor operating through an IXL reducer. The platform is driven by a 5-hp., 570 r.p.m. motor through an IXL worm gear speed reducer.

W. A. Jones Foundry and Machine Company, Chicago, Ill., has brought out a line of double-thrust, worm boxes which are intended for use where conditions do not warrant the use of a fully-enclosed, worm gear drive. They are designed to support the worm shaft rigidly, take the thrust of the worm and provide lubrication for the worm and the thrust washers. The base of the boxes is finished and the ends of the bearings are faced inside and outside. Babbitt bearings are used to support the worm shaft.

Weiss Engineering Corporation, Newark, N. J., has brought out a continuous-torque, variable-speed transmission which is said to be adapted for both automotive and industrial use. This device consists essentially of a nutating power-transmitting body called the mutor, inclosed in and concentric with a metallic sphere. The nutating body or mutor is equipped with clutch ele-

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A and B—Electric power tank and portable hand power tank, respectively, made by Carr Fastener Co., Cambridge, Mass., for use with the Dot high-pressure lubricating system.

C—Gooseneck welding torches made by The Bastian-Blessing Co., Chicago, Ill.

D—Open end Clipper belt cutter, made by Clipper Belt Lacer Co., Grand Rapids, Mich.

E—Dryvin Anchors for making attachments to masonry and brickwork. Made by Star Expansion Bolt Company, New York, N. Y.

F and G—Application of Dryvin Anchors for attaching eyelet bridle ring and combination of pipe or cable clamp and ring, respectively.

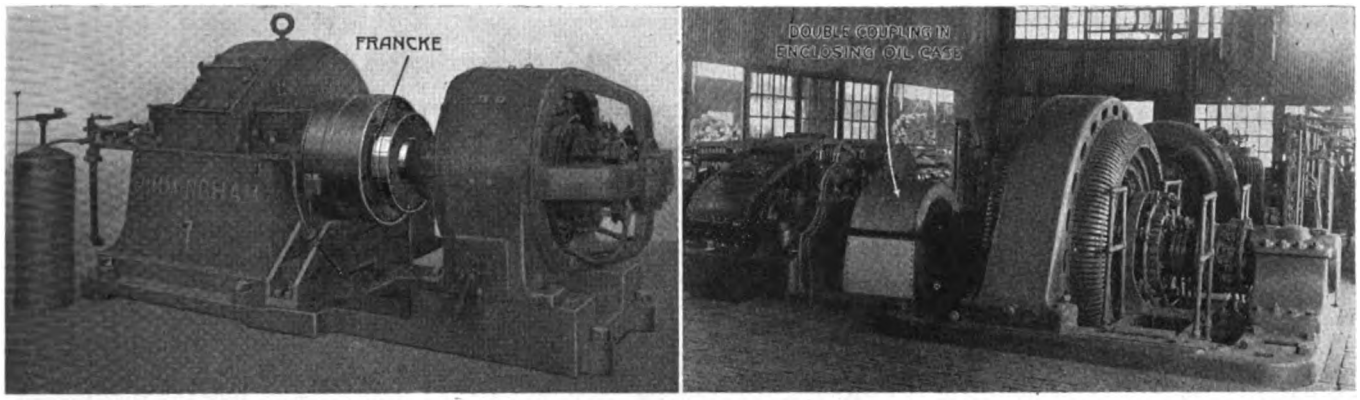
H—Flexible coupling, made by Terry Steam Turbine Company, Hartford, Conn.

I—Clipper Baby belt lacer, made by Clipper Belt Lacer Company, Grand Rapids, Mich.

J—Conway CMT unit expansion clutch, made by The Conway Clutch Co., Cincinnati, Ohio.

K—Clutch pilot ball bearing, made by Standard Steel and Bearings Incorporated, Plainville, Conn. This bearing is designed for both automotive and industrial use.

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The illustration at the left shows one of the redesigned Francke (Smith and Serrell) couplings used in combination with a pneumatic clutch brake for rubber mills and similar drives.

At the right is shown a combination shearing coupling installed on a 1,200-hp. strip mill drive in a steel plant. In case of excessive overload the bolts between the halves of the coupling are sheared off, preventing other damage.

ments that co-operate with the inside surface of the sphere, the transmission being designed so that the relative angular axial positions of the mutor and the sphere may be varied, the mutor nutated and the rotation transmitted from it. Power is transmitted from the driving to the driven member through the mutor which, receiving its movement of nutation from the driver, acquires from it a continuous movement of rotation about its own axis and transmits it to the driven member.

It is claimed that an infinite number of speed ratios between the driving and the driven shafts may be obtained without gear-shifting or the use of a clutch. Further claims are: It is highly efficient and not subject to great wear, as all the power is transmitted through ball bearings; it is positive in its transmission of power for all speed ratios and for all loads; it maintains constant, uninterrupted action during all speed variations.

Reeves Pulley Company, Columbus, Ind., has during the past year refined and perfected its variable-speed transmission in several important respects. One of the most noteworthy of these improvements is the development of a new, steel-link V-belt, which is designed for use only with the Reeves transmission. This chain is composed of hardened steel links flexibly bound together with double, frictionless, rocking pins. Leather tips which are cemented and riveted to steel tabs are securely fastened to the belt sides at an angle conforming to the V-shaped groove of the transmission disks.

It is claimed that the new steel V-belt is practically unbreakable and that, due to its extreme flexibility, it will run even and true at all positions of the disks. Also, it is self-cleaning and requires only a small amount of oil to insure proper lubrication. This belt will be furnished on new transmissions only when specified by the customer.

Clutches and Couplings

Smith and Serrell report that the high-speed-type, Francke flexible coupling which they are marketing has recently been redesigned to give it considerably greater strength, although the outside dimensions have been kept approximately the same. Couplings of this type are now made in capacities up to 6,000 hp., at 1,800 r.p.m.

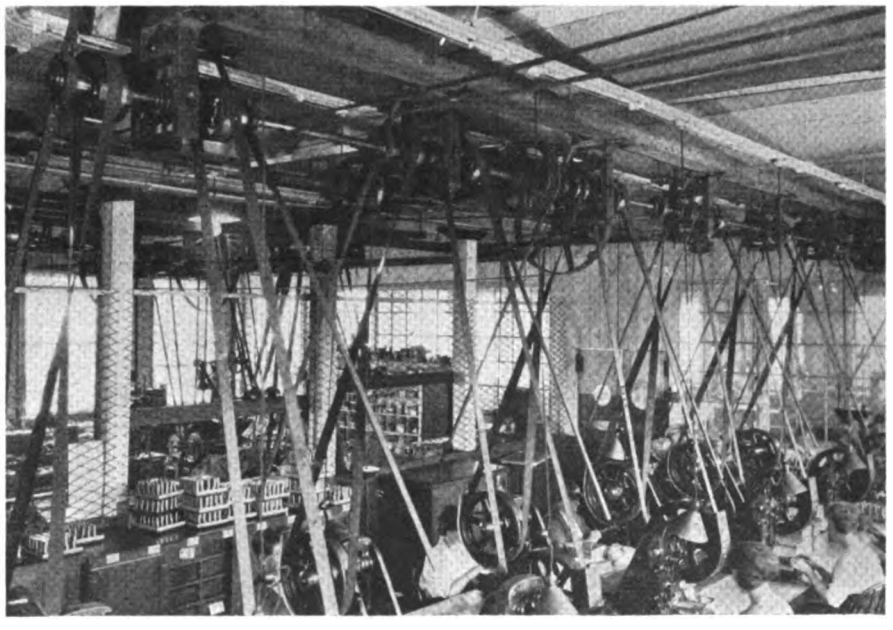
Some time ago this concern made up, on a special order from a steel mill, a combination shearing coupling having the flexible features of the Francke coupling. This coupling was installed on a 1,200-hp. drive for a strip mill and the two halves are connected by seven ⅞-in. bolts. The mill and drive is thus protected from injury when a strip doubles up or enters too cold. In one of these couplings more than 300 bolts have been broken, but more serious damage has thereby been prevented.

The Terry Steam Turbine Company, Hartford, Conn., has developed for use with all types of equipment the flexible coupling which has heretofore been used only with Terry steam turbines and reduction gears.

This coupling is of the pin-and-bushing type. One of the features to which special attention is called is that this coupling is made from steel forgings, which gives it greater

An instance where shifting of belts is eliminated by the use of friction clutches.

This shows part of a battery of 12 light bench presses which are driven directly from the lineshaft and controlled by Johnson friction clutches, in the Elmwood plant of The New Departure Manufacturing Company.



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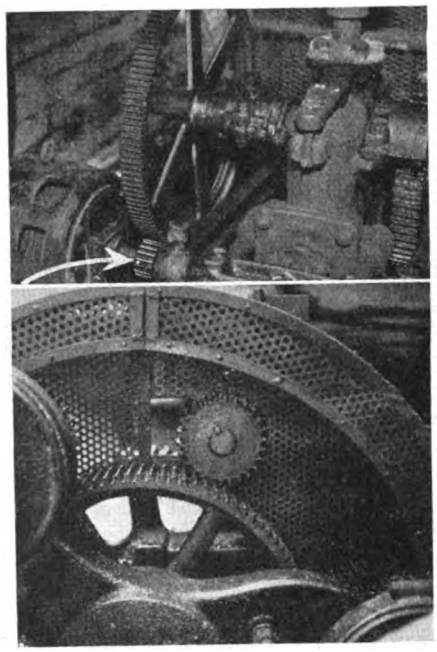
uniformity of composition and higher tensile strength. The pins are also made of steel and the cylindrical portions hardened and ground so that the bushings are free to adjust themselves under load and are prevented from transmitting any end thrust. The pins are provided with screw heads and fiber washers which, it is claimed, keep the bushings in their proper location within the driven flange.

The bushings, which are the flexible medium, are made of rubber and are ground to an exact outside diameter so that each bushing transmits its portion of the load. It is claimed that all parts of the coupling are made to limit gages and that the couplings are balanced after they have been finish-machined.

Among the advantages claimed for this coupling are: it compensates for both angular and off-center misalignment; allows free end float of connected shafts and will not transmit end thrusts; by removing the pins the shaft of either machine may be raised vertically without disturbing the other; it is easily and quickly checked for alignment.

The Conway Clutch Company, Cincinnati, Ohio, has brought out a new, type CMT, friction clutch which is claimed to be an unusually simple, self-contained friction unit, with an extensive, one-point accessible adjustment, large peripheral contact, full-length bearing for the loose member and heat-treated steel actuating parts.

On some production machines it is necessary to start and stop the machine as each piece of work is finished. This means shifting a belt from the tight to the loose pulley and back again hundreds of times a day. In such situations the use of friction clutches oftentimes presents certain desirable advantages. In this connection the Carlyle Johnson Machine Company, Manchester, Conn., reports that its friction clutches have within the past year been applied to a number of well-known production machines as standard equipment. It reports also, that there is a noticeable tendency to increase the number of friction clutches on new machines. For example, on some multiple-spindle, automatic screw machines each spindle is controlled through a friction clutch.



Celeron gears are used on these drives.

The upper illustration shows the drive for a core pump in an ice plant. The brine spray to which this drive is subjected makes the employment of iron or steel gears impracticable. Below, Celeron gears on a reel in a paper mill, where they have been in service 24 hr. a day for over four years. These gears, which are manufactured by the Diamond State Fibre Co., are made of layers of woven fabric impregnated with a synthetic resin and bonded together at a high temperature, under heavy pressure.

Miscellaneous New Developments

In addition to the equipment which has been described on the preceding pages a number of other devices of a more general nature, but which are of interest to industrial plant men, have been placed on the market during the past year. For example, the Link-Belt Co., Indianapolis, Ind., has recently added to its line of safety collars and is now marketing the "split-type."

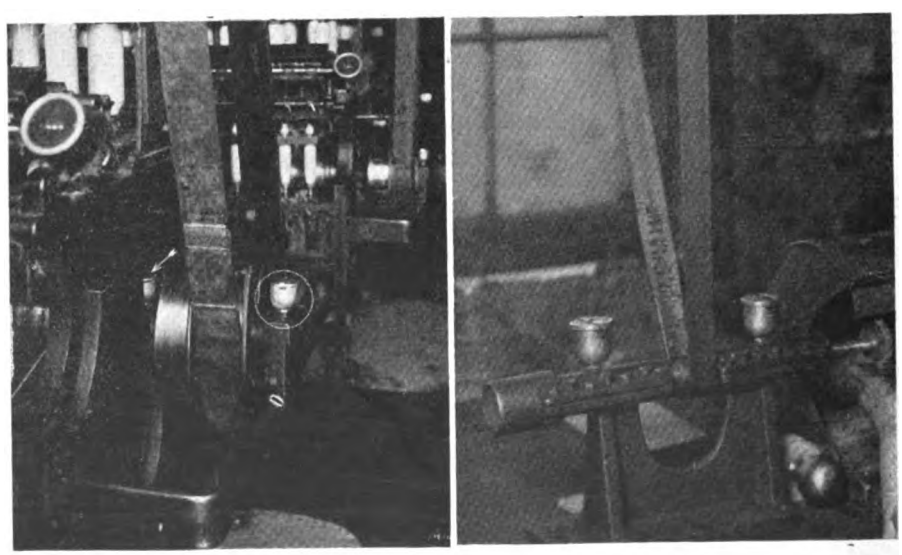
This device is intended to maintain the proper alignment of such equipment as pulleys, shaft bearings and hangers. Its design makes installation and adjustment easier, as the collar is split in two pieces. The setscrew, by which the collar is affixed to the shaft, is flange-protected.

Michigan Lubricator Company, Detroit, Mich., has developed a valve which is being sold under the trade name of "Michigan Kant Leak Maintenance Valve." This embodies several new design features. It is claimed that a double, metal-to-metal seat insures tight closing; that the packless stem prevents any leaks and that, inasmuch as no packing, washers or gaskets are used there is nothing to swell, warp or give trouble in other ways.

Oster Manufacturing Company, Cleveland, Ohio, has recently brought out a new electric pipe threader which will cut and thread pipe up to 2 in. in diameter. The machine is driven by a ⅛-hp. Westinghouse motor, which is furnished with a 10-ft. cord and plug that may be screwed into any light socket. The outfit is light enough to be easily portable and may be mounted on a service truck for transportation to any part of the plant.

Carr Fastener Company, Cambridge, Mass., has developed and placed on the market a new electric power tank and a portable hand-

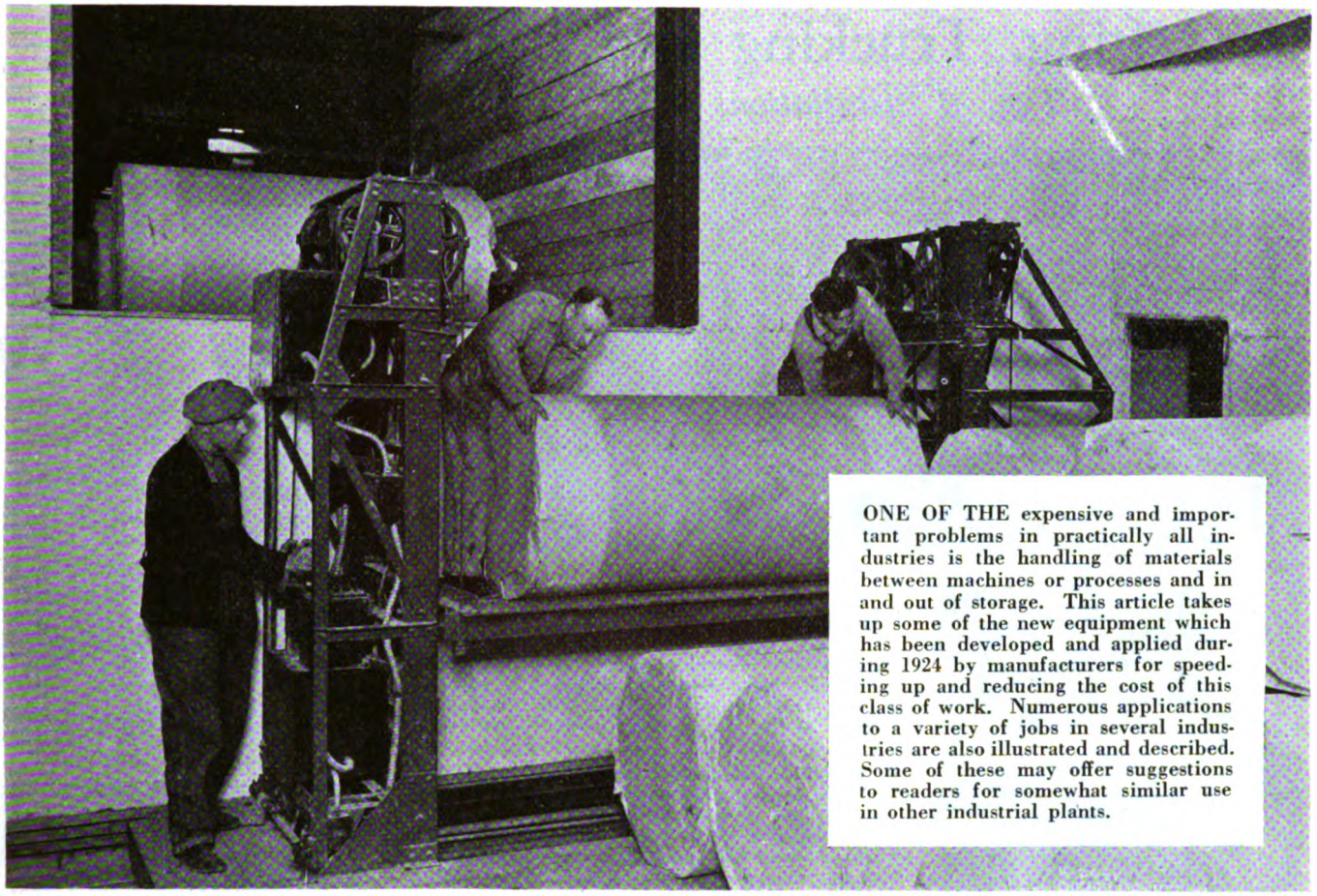
(*Please turn to page 111*)



Knorr lubricators help to solve the problem of lubricating these machines.

The left-hand view shows two of the six Knorr lubricators, made by Malcolm H. Smith Co., Inc., on a machine in a textile mill. In this mill 376 machines are similarly equipped. Previous to the installation of these lubricators considerable trouble had been experienced with oil drip and hot bearings. Right, Knorr lubricators on a high-speed grinder head.

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ONE OF THE expensive and important problems in practically all industries is the handling of materials between machines or processes and in and out of storage. This article takes up some of the new equipment which has been developed and applied during 1924 by manufacturers for speeding up and reducing the cost of this class of work. Numerous applications to a variety of jobs in several industries are also illustrated and described. Some of these may offer suggestions to readers for somewhat similar use in other industrial plants.

This double-post Economy tiering machine hoists or lowers or travels on the track under the direction of the operator at the left. Power is obtained from third rail. It is used for handling paper from the receiving chute to and from storage and then places it on the runway to the press.

Typical Jobs Where

Material Handling Devices Pay for Themselves

By Doing Easily, Quickly and at Lower Cost Back-Breaking Labor Jobs and Other Lifting, Moving and Piling Tasks Which Call for Excessive Labor Charges

By FRANK E. GOODING
Associate Editor, Industrial Engineer

NOT MANY new developments in material handling equipment were made during 1924. This was partially due to the lack of consistent demand. Also there was no shortage of labor. In addition, several manufacturers had brought out new types of equipment during the past two to four years which had rounded out their lines of equipment materially and enables them to handle with such special adaptations of their equipment as may be necessary, practically any line of work. A number of these adaptations will be described and illustrated in this article.

However, production men are taking material handling equipment more seriously and it is less difficult to convince them of its advantages over methods of doing such work by hand. Considerable effort has been directed toward making a more careful study of the material handling problem both from an equipment and a methods viewpoint. This has been particularly true in the development of special devices for holding or containing the work during handling. While much had been developed along this line previously, additional efforts have been directed toward the development of better methods of controlling the work and placing it on a more efficient basis.

Trucking is in many plants now operated on a schedule basis instead of hit or miss as has been the case quite frequently in the past. This alone has in some cases reduced the trucking force 50 per cent. In addition, much has been accomplished by a rearrangement of machines and placing them close together whereby the work does not have to be handled or trucked between machines. Because of the short distances, the work is passed from machine to machine either by hand or on conveyors. This work has, of course, been carried on for some time in the automotive plants but other industries are also taking advantage of it, with gratifying results.

Making these announcements of changes of design in various classes of equipment, does not indicate, however, that the companies mentioned

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Lifting, Trucking and Piling Operations

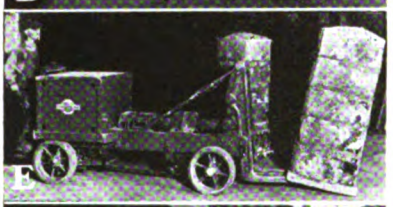
Typical Installations from Ten Industrial Plants

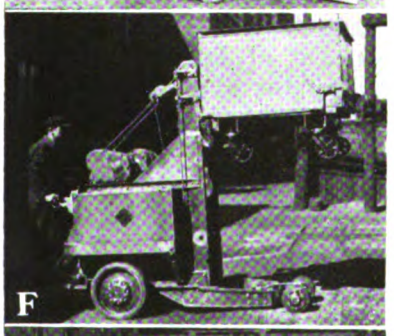

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A—For many types of industrial trucking, where the distance is not great and the load not excessively heavy, hand-lift, elevating-platform trucks are becoming widely used. Here 32 cases of Orange-Crush are handled as easily as one. This Barrett lift truck will lift from an angle of 45 deg., which facilitates its use in aisles.

B—Hand-lift, elevating-platform trucks are also widely used in the printing industry for handling paper, because the paper can remain upon the platform until used without rehandling which would soil or damage a certain percentage of the sheets. This Revolvator lift truck is in use in a New York printing plant.

C and D—This special Elwell-Parker truck is used to pick up, stand on end, elevate and stack or tier heavy rolls of cloth, bales, barrels, and similar bulky objects. The load, which may be either standing up or lying down, is picked up on the apron, lifted and turned either to the vertical or horizontal and stacked 6 ft. high.

E—Several manufacturers have devised lift trucks for use in handling pots either in or out of annealing furnaces. This Crescent truck is one of three trucks in use in an Eastern foundry.

F—This Hi-Lo Elwell-Parker truck will place 2,000-lb. loads in trucks or lift the dump-bottom body high enough for the load to be dumped into bins or vats.

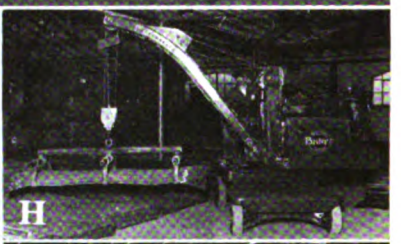
G—Ordinarily tiering machines or stackers are used for elevating loads which are too heavy for men to handle. In this case, a load consisting of a number of small boxes of parts is elevated so that one man can store them, whereas, previously a man on the floor and one on the bin ledge were required. The sliding platform is held centrally until the load is elevated. By means of a cable control the man on the ledge can change the height of the platform.

H—Units of material which are small can be handled effectively by grouping. Slings such as this are very effectively used for handling loads of sheets. This Baker crane truck not only lifts, but carries and piles, as well.

I—This shows how effectively lift trucks and stackers can be used in combination. The racks enable the material at Barrett-Craven's stock room to be piled five tiers high, whereas, if only the lift truck were used, more than five times this much floor storage area in square feet, would be required.

J—While the average industrial plant has use for long-boom crane trucks in some places and short-boom cranes in others, this telescoping Elwell-Parker truck gives this dual or general all-around service.

K—Here 1,800-lb. rolls of paper are piled with this Revolvator. The same equipment is used to remove the rolls from storage.


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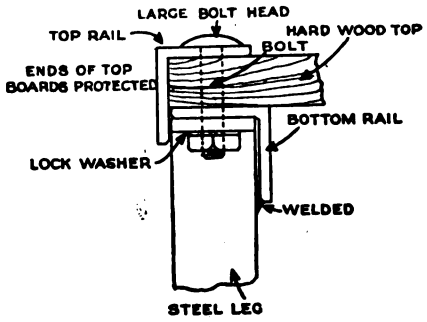
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are the only ones producing similar equipment, as these are merely statements that the company mentioned has added the special features described. Frequently, they differ somewhat from that used by another manufacturer, although in many cases each accomplishes practically the same purpose.

Some Developments of Hand and Power Industrial Trucks

As a large portion of industrial handling is done by trucks, it is natural that much of the development during the past year has been in this field of equipment. This was also true of the previous two or three years.

About a year ago, Barrett-Cravens Co., Chicago, Ill., brought out a new type of hand-lift elevating platform truck which lifts with the handle at an angle of 45 deg. to either side so as to facilitate operation in aisles. The truck is of all-steel construction with roller bearings and Alemite oiling system. The lifting latch connects and disconnects automatically and the latch is equipped with a hardened steel roller which rolls in and out of the catch instead of sliding, thus minimizing wear.



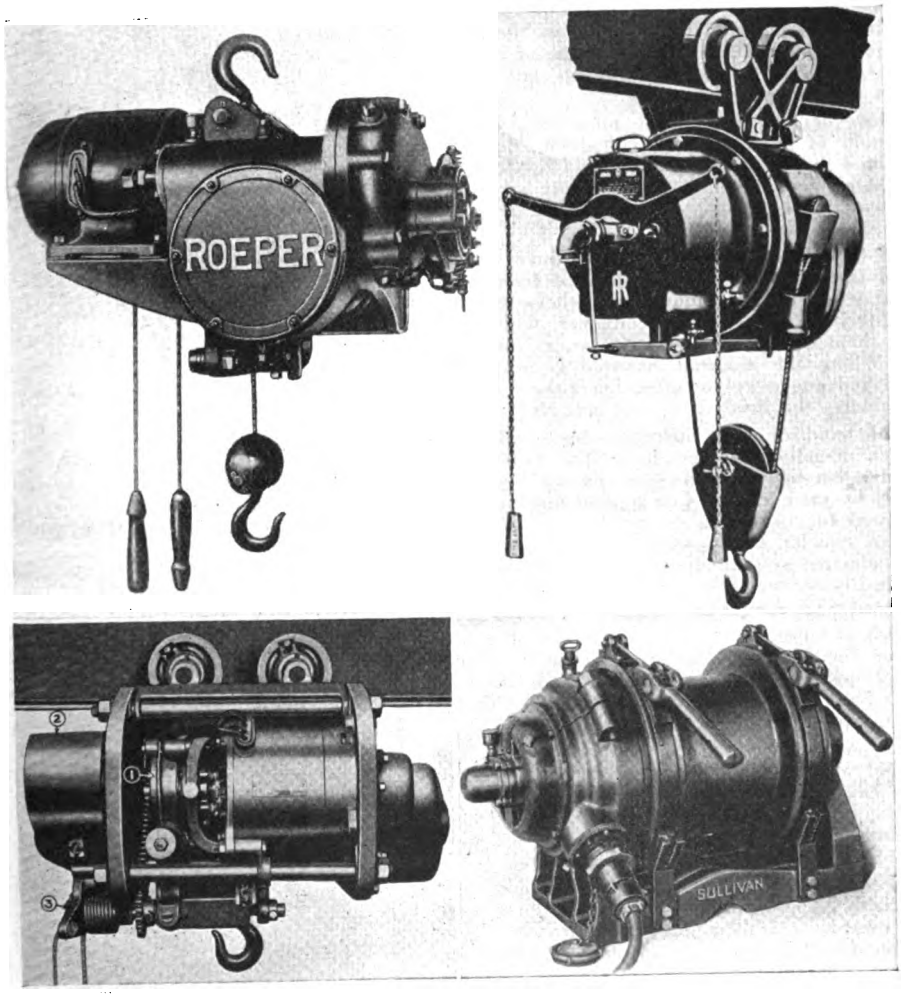
Improved construction of Barrett platform for hand-lift trucks.

In this platform for hand-lift trucks, the legs are welded to the angle-irons as shown. The other angle-irons protect the ends of the platform boards and give a firm bearing surface for the bolt heads and the legs.

One example of a special application of a hand-lift truck to the work it is to perform is shown by the special Jacklift hand truck, Lewis-Shepard Co., Boston, Mass., shown in the right-hand illustration at the bottom of page 69. This truck, which has a high lift of 6 in., is equipped with a turn-table to remove and move products that are delivered to or from a machine on rolls, such as some products of rubber and textile machines. For example, to remove a heavy roll the turn-table is placed at right-angles to the carrying platform as shown in the illustration. The uprights of the turn-table are placed under the ends of the axle running through the roll. Elevating the platform raises the roll sufficiently to lift the roll axle clear of its bearing supports. The truck is pulled out and the turn-table then revolved parallel to the carrying platform of the truck so that it can pass through narrow aisles or openings.

In some plants this type of work is done by hand hoists although many concerns have installed electric hoists for the work. Attachments like this will enable one man to remove or insert a roll alone and with the same equipment move it to its destination and similarly place it in storage or in another machine by merely reversing the process. It is to such ingenuity as this in applying special grasping or holding devices to standard material handling equipment that industrial men are now devoting much of their time and on which they depend for making increased savings. This truck could back up to a machine, lift the roll and be away before the roll could be lifted by some of the common methods of doing this work.

Manufacturers of electric industrial trucks and tractors have also brought out several new types. One of the most interesting of these, which was developed by the Elwell-Parker Electric Company, Cleveland, Ohio, is an electric elevating "Tructor" arranged for handling rolls, barrels, bales or boxes. These are handled by a revolving cradle attached to the front of the elevating platform as shown in one of the accompanying illustrations. This machine is primarily designed for pick-



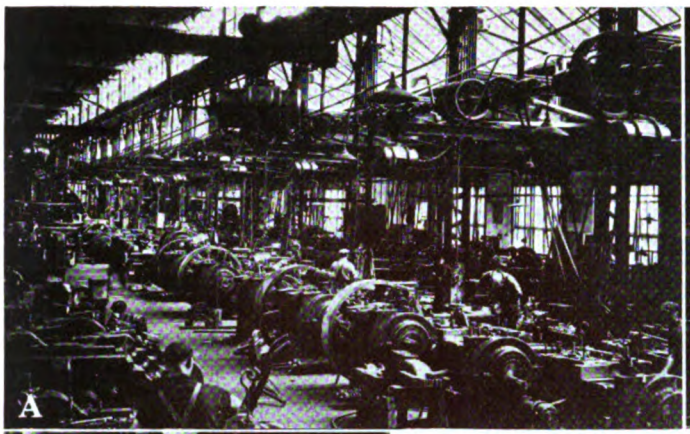
Four electric and air hoists developed during 1924.

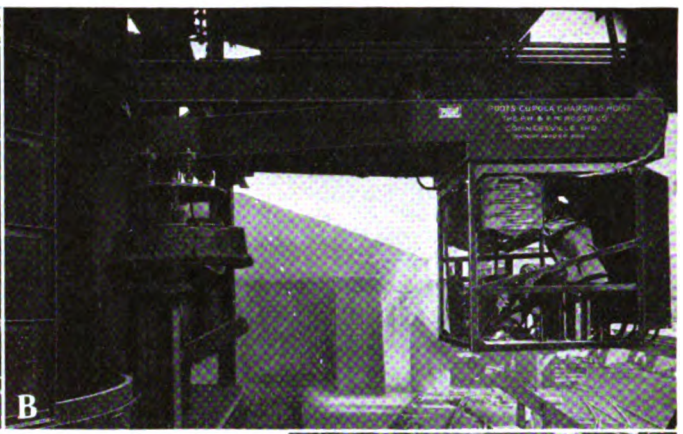
The Type R electric hoist (upper left) was brought out by Roeper Crane & Hoist Co., Reading, Pa., is available in capacities ranging from 500 to 4,000 lb. and contains an automatic stop of the trip-lever type which may be adjusted for any length of hook travel. A mechanical brake acting in series with the controller helps to stop quickly. Ingersoll-Rand Co., New York City, brought out the new type of air hoist (upper right). The outstanding characteristics are briefly: low headroom required; relatively light weight; automatic brake to hold the load if air supply fails; a graduated throttle for close regulation of lifting and lowering speeds. Some features of American Engineering Co., Philadelphia, Pa., new Lo-Hed hoist (lower left) are automatic holding and lowering brakes, a safety device to check the hoist and throw off current at upper limit of travel, roller bearings and automatic system of lubrication. The Sullivan Machinery Co., Chicago, Ill., electric hoist (lower right) can lift 2,000 lb. vertically at 110 ft. per min. The 6½-hp. specially designed d.c. or a.c. Westinghouse motor is enclosed within the hoist drum. Direct current motors are compound wound, with series characteristics.

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Handling Materials with Hoists and Conveyors

Ten Examples of Equipment Applications on a Variety of Jobs


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A—Here practically every machine and assembly space is served by an Ingersoll-Rand air hoist. In heavy-machine shops, such as this, a large gang of helpers would otherwise be necessary.

B—This Root cupola-charging hoist may be operated with either magnet, dump-bottom bucket or grab bucket for handling different materials.

C—Economies have been effected in many textile plants through the use of pneumatic conveyors, such as this Sturtevant installation, for handling cotton, wool and many other light materials between operations and to and from storage.

D—These Harnischfeger Corp. cranes carry a 45-in. and a 65-in. Ohio round mill-type, lifting magnet for storing and classifying the miscellaneous scrap which is to be reclaimed or sold in the reclamation yard of the Chicago, Burlington & Quincy R. R. Because of the heavy weight and comparatively low value of the material, handling it by a magnet is one of the most economical methods.

E—Conveyors are one of the most advantageous methods of handling material which "flows" in quantity between given points. This Standard apron conveyor handles either empty or packed cases of yeast between the packing, storage and shipping departments.

F and G—Here two Jeffrey apron conveyors are used to take buckets of white lead from basement storage to the floor above where they are transferred to a portable conveyor, which carries them directly to the car door, as shown in *F*. Where the material handled is not easily damaged one conveyor often feeds the next and eliminates the need of a man between.

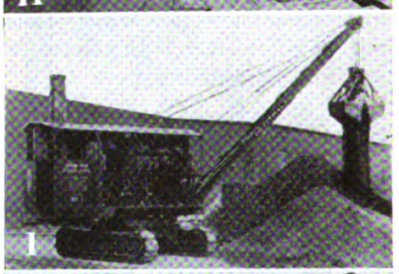
I—Coal handling and miscellaneous yard work which usually requires large gangs intermittently, can be done more easily and economically by yard cranes. One type of machine well adapted for this work is the Industrial Works 10-ton crawler crane, which is built for either gas, electric or steam power drive. This crane is readily converted into a shovel or pile driver, or used with a hook or magnet for lifting.

H—This is another example of the use of a conveyor for "flowing" material. Here a Jeffrey wood apron conveyor with cleats carries kegs of nails from the nail machines to trucks, as shown here, bound for storage or car-loading.

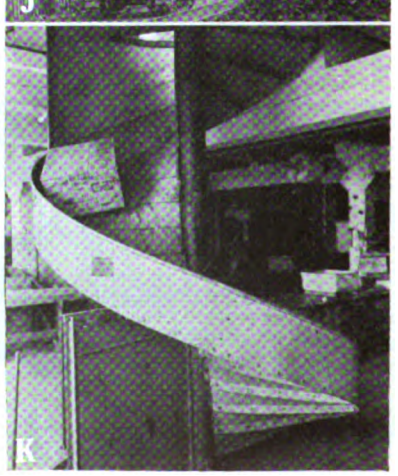
J—One of the problems in connection with the use of an electric lifting magnet is to care for the wire supplying power to the magnet. Here a Mogul Type Reelite (Appleton Electric Co.) is installed on a Harnischfeger Corp. locomotive crane used for miscellaneous handling.

K—Spiral chutes or other gravity conveyors do much to relieve elevators by handling materials downward. This is a Standard Conveyor installation. for handling cases of shoes in the plant of the U. S. Rubber Co.

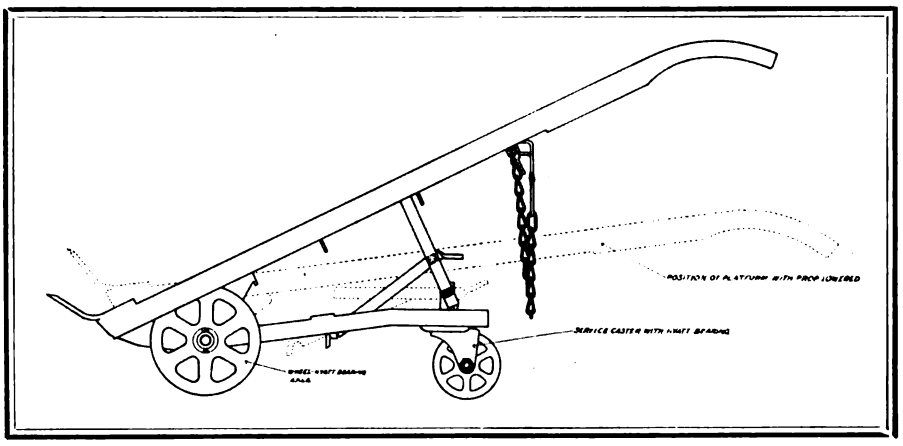

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A modification of a two-wheeled truck with a swivel trailer for carrying heavy loads.

The handles of this truck are elevated vertically until the tip is worked under the load to be lifted as in the ordinary warehouse truck. When the load is lifted, however, the body of the truck can be made to recline as shown in the sketch. The operator merely pushes or pulls the load as in an ordinary truck without being required to support it nor to hold it up or lift it again in case he should let loose of it. The chain can be hooked over boxes or other packages, so as to hold them when loading the truck. This truck will handle 1,500 lb. which would be a heavy load for at least two men on the ordinary two-wheel truck.

ing this material up, whether it is lying down or standing up, standing it on end if desired and then raising it to pile up to 6 ft. high. This machine has two separate motors for operating the hoist; one raises and lowers the load and the other revolves the apron or cradle to stand the material on end or to lay it down.

Combination machines, of this and other similar types that will pick up, carry and stack are doing away with many of the back-breaking jobs in material handling. A 600- or 1,000-lb. barrel or bale can be handled and stacked by this machine and the operator easier than a man can handle a 100-lb. sack. Usually a helper speeds up the work by hooking and unhooking the chain which goes around the load. This also makes warehouse space more usable by piling several tiers high.

Another development by this company is a "Hi-Lo" tructor with an end-dump body fitted with wheels built on the platform. This will lift 2,000 lb., or from 27 to 100 cu. ft. of bulky material, transport it and elevate so that it can be dumped into a bin, car or hopper as required.

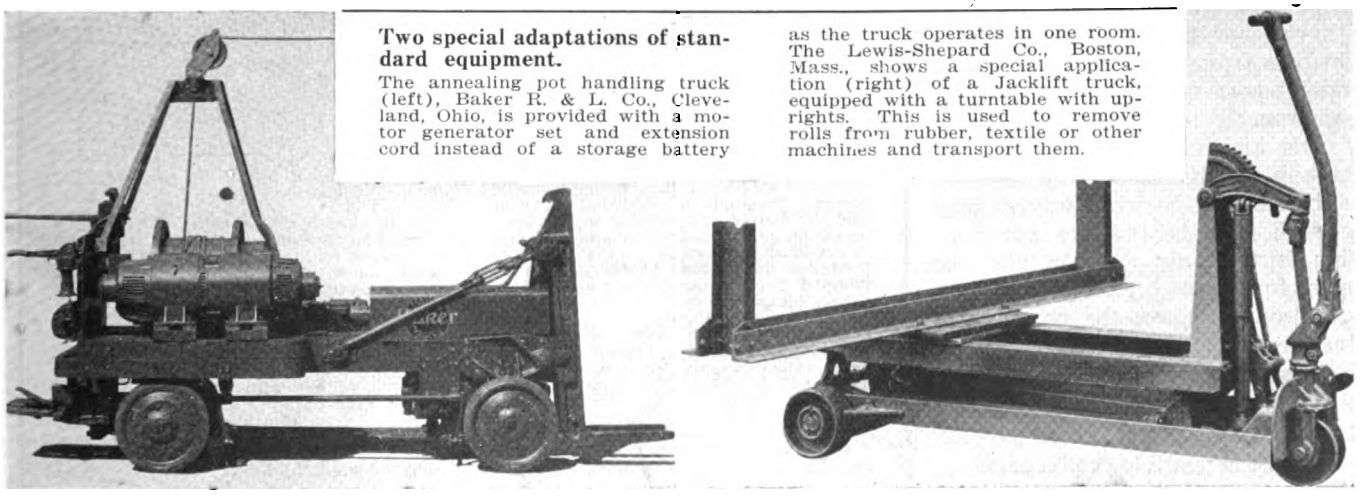
Still another development is a telescopic crane boom for attachment to the Elwell-Parker crane truck. This enables the crane to be used for high work either outside or where a ceiling is extra high as in a warehouse or railroad shop and telescope so that it can be used within cars or in buildings with low ceilings without extending the boom out so near horizontal that it cannot lift heavy loads. Improvements of this nature make equipment more of a general-duty type and help meet the varying demands put upon it in the average industrial plant.

The Baker R. & L. Co., Cleveland, Ohio, has also brought out some improvements on its locomotive type cranes on an industrial truck. This type of crane is used quite widely around railroad repair shops for holding pumps, side rods and other heavy parts while they are attached, and for high piling, serving machine tools and handling heavy material. Another interesting application was made of a Baker truck for handling annealing pots in a malleable iron foundry. Instead of using a storage battery, this truck was provided with a motor generator set connected to a standard power outlet through an extension cable. In this case, the truck was to be used only in one room. Ordinarily such industrial trucks must have a wider range of travel than is possible without storage batteries.

Another company which has done considerable development in extending their line of electric trucks during the past year is The Crescent Truck Co., Lebanon, Pa. One of these is a special elevating platform truck which has a height of 17½ in. from the floor when the platform is down and 22 in. when the platform is raised. This uses 15-in. wheels with tires 5 in. wide, which enables it to be used in yard and general purpose work. It is constructed for heavy service with a lifting capacity of 3,000 lb.

Another addition to the Crescent line is a special truck built for handling annealing pots in and out of the furnaces. Incidentally, the installation of this truck, shown at *E* page 66, and two other industrial trucks for handling loose materials enabled the company to get along with 20 less laborers than formerly had been required continuously for this work. Also, a big saving has been made in that these trucks can handle material around the plant in such quick time that men are not held for shortage of supplies, which has materially reduced the overtime formerly necessary.

In addition to their new type of lift truck, the Barrett-Cravens Co.,



Two special adaptations of standard equipment.

The annealing pot handling truck (left), Baker R. & L. Co., Cleveland, Ohio, is provided with a motor generator set and extension cord instead of a storage battery as the truck operates in one room. The Lewis-Shepard Co., Boston, Mass., shows a special application (right) of a Jacklift truck, equipped with a turntable with uprights. This is used to remove rolls from rubber, textile or other machines and transport them.

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Chicago, Ill., brought out a "Steeleg" platform for lift trucks. The feature of this is that the leg is welded to an angle-iron to make the platform more rigid as shown in the sketch at the top of page 67. This strengthens the platform at its weakest point.

A new type of trailer to be used in connection with industrial tractors was brought out recently by The Service Caster & Truck Co., Albion, Mich. This consists of a platform with uprights at one end to make it a push truck, which travels on a pair of swivel casters at one end and solid casters at the other. Another development of this company is a heavy-duty caster, equipped with Hyatt bearings, and hardened steel rolls. The construction of this is shown and described in connection with the drawing below. This company also brought out a special all-steel tri-wheel truck, which is a special modification of the two-wheel hand warehouse truck, to be used for handling heavy loads. The general features of it are shown in the drawing on page 69 and the description accompanies it.

Two other new types of heavy-duty casters have also been introduced during the past year by the Bond Foundry & Machine Co., Manheim, Pa. These are both illustrated and described on this page.

Development in Tiering Machines, Stackers and Elevators

Most of the developments during the past year in tiering machines, stackers and elevators have been toward improving features of construction and also in providing special attachments or building equipment of special size and capacity to do particular tasks. For example, The Economy Engineering Co., Chicago, Ill., built a special double-post paper handling tiering machine for use in a newspaper plant. This lifts the platform from both ends and travels under power on a track as may be seen from the illustration at the head of this article. Power is obtained through special third rail recessed in the side of the track way as may be seen just behind the operator. This is not only used to pile the paper four tiers high to the ceiling but also to remove the paper from storage and put it on the runway to the pressroom, which is shown as about on a level with the operator's shoulders.

When it is possible to pile paper or other warehoused or stored material entirely to the ceiling the cubic contents count as well as floor space. Four tiers high multiplies the value of the floor space by four. Portable elevators make a cubic foot near the ceiling as valuable as a similar space near the floor.

Another type of portable double-post elevator for handling paper rolls, which is moved by hand on its wheels instead of a track, was developed by the Barrett-Cravens Co., Chicago. Other developments in this equipment brought out by this company were gear housings, a governor for controlling when lowering under load and other special features of construction.

An attachment for the Lewis-Shepard Co., Boston, Mass., stacker, is a special sliding platform built for use at the plant of the Wayne Tank and Pump Co., to be used in connection with storing material in bins, illustration *G*, page 66. Formerly one man stood on the floor, the other on the ledge and passed material from one to the other. By using a cable control, one man on the ledge can operate it to the correct height for proper unloading, or even change its height if part of the material should go in a lower bin. When the load is at the proper height a pin which locks it in the center of the platform is removed and the load rolled to one side. There is a limit, of course, as to the distance which any given weight may be shifted to the side.

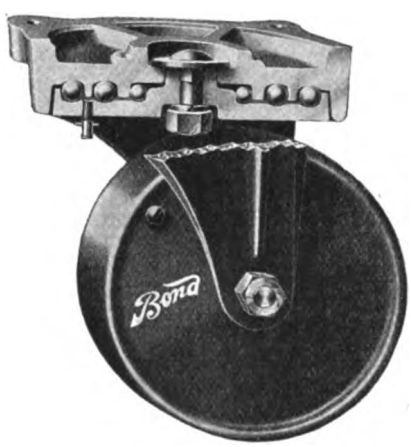
In redesigning the revolvator, manufactured by Revolvator Co., Jersey City, N. J., silent chain drive is now used. Other attachments have been over-travel limit stops, safety attachments to catch the platform should the cable break, and a new design of floor locks, together with other improvements which facilitate the operation.

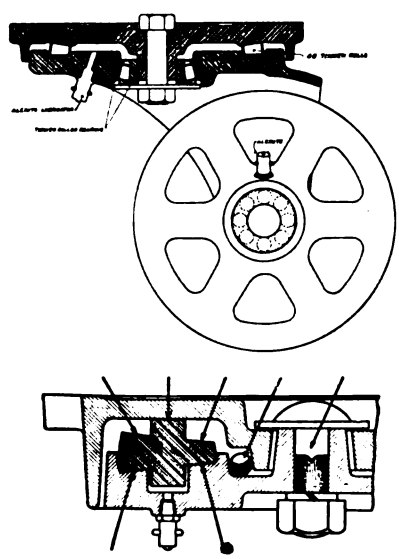
The Economy Engineering Co., Chicago, has provided a special platform which may be attached to any of its various types of tiering machines so that the operator can ride up with the load. This is detachable so that it may be hooked on any of the three sides of the platform. Where it is necessary for the platform to come down close to the floor, a special folding step is used. Push button control from the platform is usually provided for machines where the operator rides with the load.

The Standard Conveyor Co., St. Paul, Minn., has also brought out several improvements in constructional features in its piling machine.

During the past year several electric and air hoists have been developed either to add sizes to already

(Please turn to page 112)

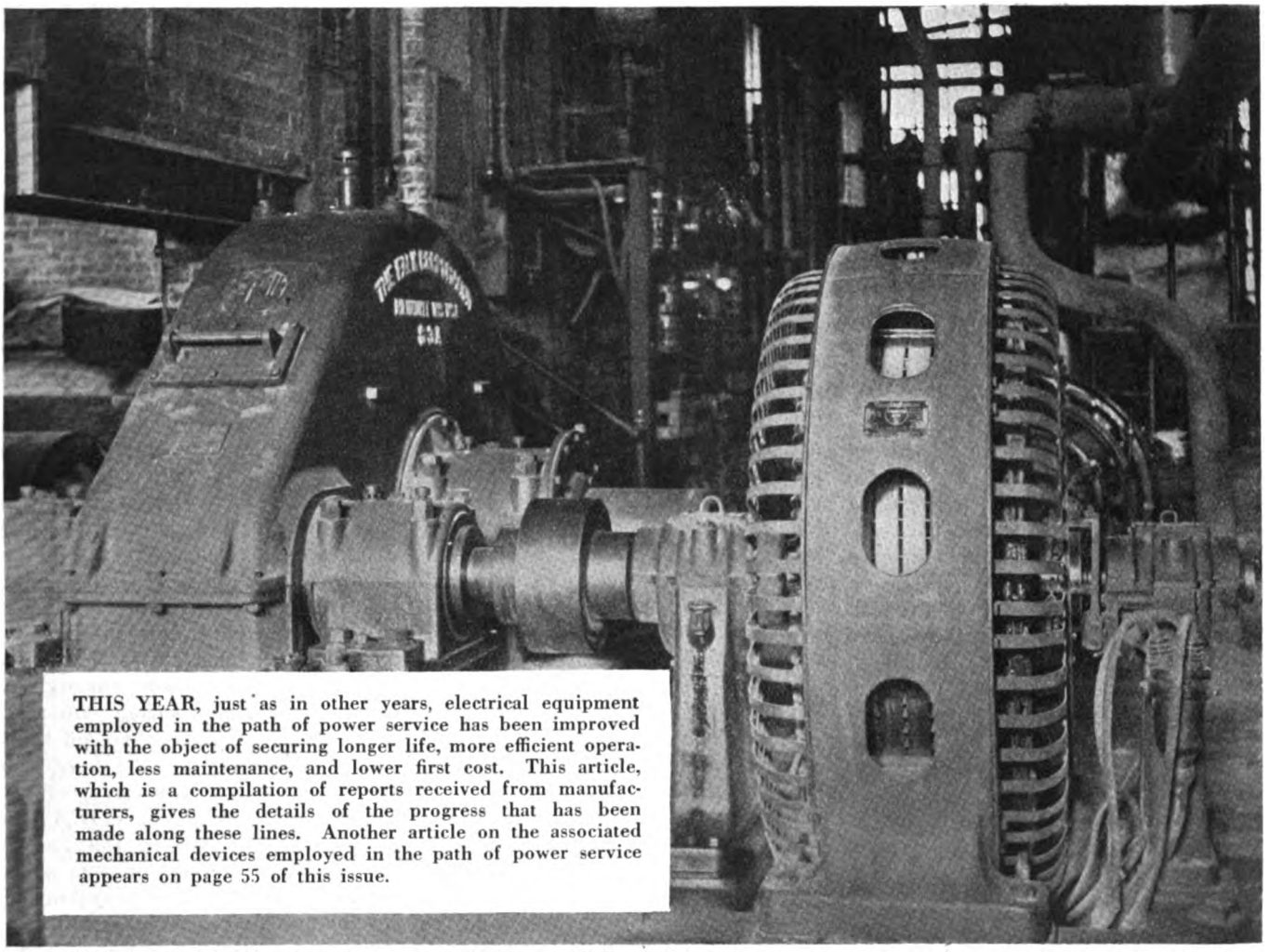




Three designs of truck casters for heavy-duty service.

Production men are realizing the value of roller or ball bearings in both the axle and swivel of the truck or trailer casters because of reduced friction and the better opportunity to lubricate properly. To meet the demand for heavy-duty operation the Service Caster & Truck Co., Albion, Mich., developed the caster with two sets of Timken tapered rolls in the swivel as shown in the drawing at the upper right. The wheel axle is provided with Hyatt bearings. In addition, two other types of heavy-duty casters were developed by Bond Foundry and Machine Co., Manheim, Pa. One of these, the triple ball race caster, has two large diameter steel balls placed to carry the load while a third, and smaller ball is located near the king bolt to absorb side shocks. The square king bolt fits into a square hole, the nut turns with the bolt and so does not work loose. The swivel is fitted with Alemite oilers. This caster is designed for unusually hard service or on loads which have been considered too large for anything but crane transportation. The other swivel caster (lower right) contains two races, one of which uses tapered rollers with shoulders and the other high-carbon steel balls. The rollers carry the weight of the load and the balls protect the king pin from shock. Any Bond standard wheels may be used.

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THIS YEAR, just as in other years, electrical equipment employed in the path of power service has been improved with the object of securing longer life, more efficient operation, less maintenance, and lower first cost. This article, which is a compilation of reports received from manufacturers, gives the details of the progress that has been made along these lines. Another article on the associated mechanical devices employed in the path of power service appears on page 55 of this issue.

This synchronous motor is driving a rubber mill line. It is equipped with improved dynamic braking equipment which is said to give a reliability comparable to the direct-current drive used on calenders. No clutches or friction brakes are used on this application. Details concerning the dynamic braking equipment are given in the following article.

Typical Developments In the Use of

Electrical Devices in the Path of Power Service

That Represent the Combined Efforts of Users and Manufacturers to Improve Operation, to Reduce Maintenance, and to Modify Existing Power Drive Equipment to Meet Changing Requirements

By ARTHUR J. WHITCOMB
Associate Editor, Industrial Engineer

WHILE many of the developments in industrial equipment during the past year have been along conventional lines, there have been numerous detailed improvements that will reduce operating costs enough to make an investigation of these new products decidedly worth the time so spent. Industrial motors have been improved in ways that are expected to greatly reduce maintenance costs on them; improved motor applications have been made which have increased production; new types of control, improved resistors, new forms of limit stops and safety features have all been incorporated in control developments during the past year.

Great progress also has been made in lighting equipment that is dust-tight.

One of the first large installations of automatic equipment in a steel-plant substation has been completed. Progress has also been made in industrial heating. Who then can say that no progress has been made in industrial electrical equipment during the past year?

To help the readers of INDUSTRIAL ENGINEER keep abreast of the times, a review of the recent developments in electrical equipment has been prepared with the idea that in this improved equipment the reader may see new ways of increasing production, decreasing operating cost and insuring more reliable and satisfactory operation.

Let us now consider the developments more in detail.

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Industrial Motors

General.—Development in industrial motors during the past year has taken place along the lines of bearing improvement, gas- and dust-tight enclosures, and better operating characteristics on synchronous motors.

Let us first consider the situation in regard to motor bearings. The Westinghouse Electric & Manufacturing Company reports that improvements have been made in the design and construction of bearings in oil-ring bearing motors, resulting in a reduction of oil leakage, also that a refill feature has been added to all grease cup lubricated standard motors whereby cups may be refilled without removing them.

On the other hand, that the ball and roller bearing motors have been a contribution appreciated by industry is shown by reports of Fairbanks, Morse & Company of Chicago, Ill., that 75 per cent of the motors now produced by them are equipped with ball bearings.

An increasing demand for motors with ball or roller bearings is also reported by the Howell Electric Motors Company of Howell, Mich. As a result, it added to its line a motor which is fitted with tapered-roller bearings.

The maker states that this bearing is very rugged, having lapped rolls made of molybdenum steel, which should last as long as the motor without additional adjustments after leaving the factory. However, should they wear so as to allow play in the bearings, the maker reports that they can be easily taken up by removing shims between the outer grease cap and bearing housing.

This company further states that grease retainers are used in all roller-bearing motors, so that any horizontal motor can be operated in any position, whether vertical or horizontal, as these grease retainers hold the grease in the bearing.

Special attention has been given to the interest expressed by engineers in the use of ball and roller bearings in electric motors, by The Reliance Electric & Engineering Company of Cleveland, Ohio. Both its type T direct-current motors and type AA squirrel-cage motors are now equipped when desired with either ball or roller bearings.

The Reinhard Electric Motor Company of Cleveland, Ohio, points out that it builds nothing but ball-bearing motors equipped with Hess-Bright, single-row, deep-groove ball bearings. This company also reports that it has standardized on Alemite fittings and Alemite lubricant for lubricating these bearings.

In connection with the development of ball and roller bearing design, the opportunity has been offered to improve on the construction of enclosed dust-tight motors. The Reliance Electric & Engineering Company reports that with the usual construction, it has not been possible to keep out all dust under the conditions found in coke and sintering plants and through the use of ball or roller bearings, this company has devised a dust-tight construction for the bearings. A further improvement is the use of solid end brackets for the back end and solid brackets having hand hole covers at the front end. The seats for the covers are machined. The covers are machined and fitted with rubber gaskets, thus making sure of really dust-tight joints. This construction is the same as used for water-tight motors for navy use.

The General Electric Company informs us that since it is unsafe to operate even the enclosed type of direct-current motor in the presence of vapors from gasoline, ether, and the like, a special construction has been adopted for both motors and control apparatus.

The Electro Dynamic Company of Bayonne, N. J., has developed a new ball-bearing, water- and gas-tight motor, which it states will operate with safety in places where explosive gases exist.

The Westinghouse Electric and Manufacturing Company reports that an oil-well motor having an enclosed collector has been placed in operation and has proved highly successful. A group of 20 induction motors designed for operation in an atmosphere containing one-half of one per cent of acetone have been developed by the General Electric Company. These motors are of the enclosed ventilated type, as shown in an accompanying illustration, taking air from outdoors through a pipe to the top of the motor and discharging it through holes in the side of the stator frame.

In the manufacture of its improved motors and generators, the Lincoln Electric Company of Cleveland, Ohio, reports that the operation of arc welding plays an important part. On these motors, the end frames are made by rolling a standard steel angle in the shape of a ring and welding the ends together. The feet are drop forgings and are welded to the angle steel and frame. The fan blades for the ventilation of the motor are welded to the rotor. Finally, the copper rods or winding of the rotor are welded to the short-circuiting rings.

Direct-Current Motors.—A noteworthy advance in direct-current motors has been made by the Liteweld Company of Cleveland, Ohio. This company reports that it has made improvements in the field construction—the heaviest part of any motor or generator—that reduce the amount of material required per horsepower for a given temperature rise and overload capacity to only about one-half the weight of the ordinary type of motor. This reduction in weight results in a reduction in cost, the company informs us. The company also states that these results are obtained through a divided-pole construction which enables the material in the field to be used more effectively. The ordinary induction motor of a given speed and capacity has an air-gap only 35 per cent to 40 per cent of that of the corresponding direct-current motor. In the case of the direct-current motor the air-gap has to be made longer in order to reduce the cross-flux due to the load carried by the armature. The Liteweld design is said to practically eliminate the cross-flux by forcing it to take a path of very high magnetic resistance or reluctance and this avoids the necessity of using this large air-gap, thereby permitting the use of the same sized gap in a direct-current machine as in the induction type. The manufacturer further states that since less total flux is required by this construction, the field coils can be reduced in size and, therefore, permits the radial dimension of the field system itself to be reduced.

An important development for direct-current armatures is the "Frog Leg" winding brought out by the Allis-Chalmers Manufacturing Company of Milwaukee, Wis. The maker states that the previous limitations of direct-current machines, due to the difficulties of commutating heavy loads or rapidly fluctuating loads, are now removed, and that this company is now able to offer machines having commutating qualities far beyond anything previously built.

Induction Motors.—A new company has entered the field of induc-

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tion motor manufacturers. This company, The Linzee Electric Motor Co., of Mansfield, Ohio, has taken over and assumed control of the Phoenix Electric Company. For the present, the new company will continue to manufacture the old type a. c. motors and will in addition to this line put on the market a complete new line of polyphase induction motors to be known and sold under the trade name, Linzee Type L. B. and Type L. S.

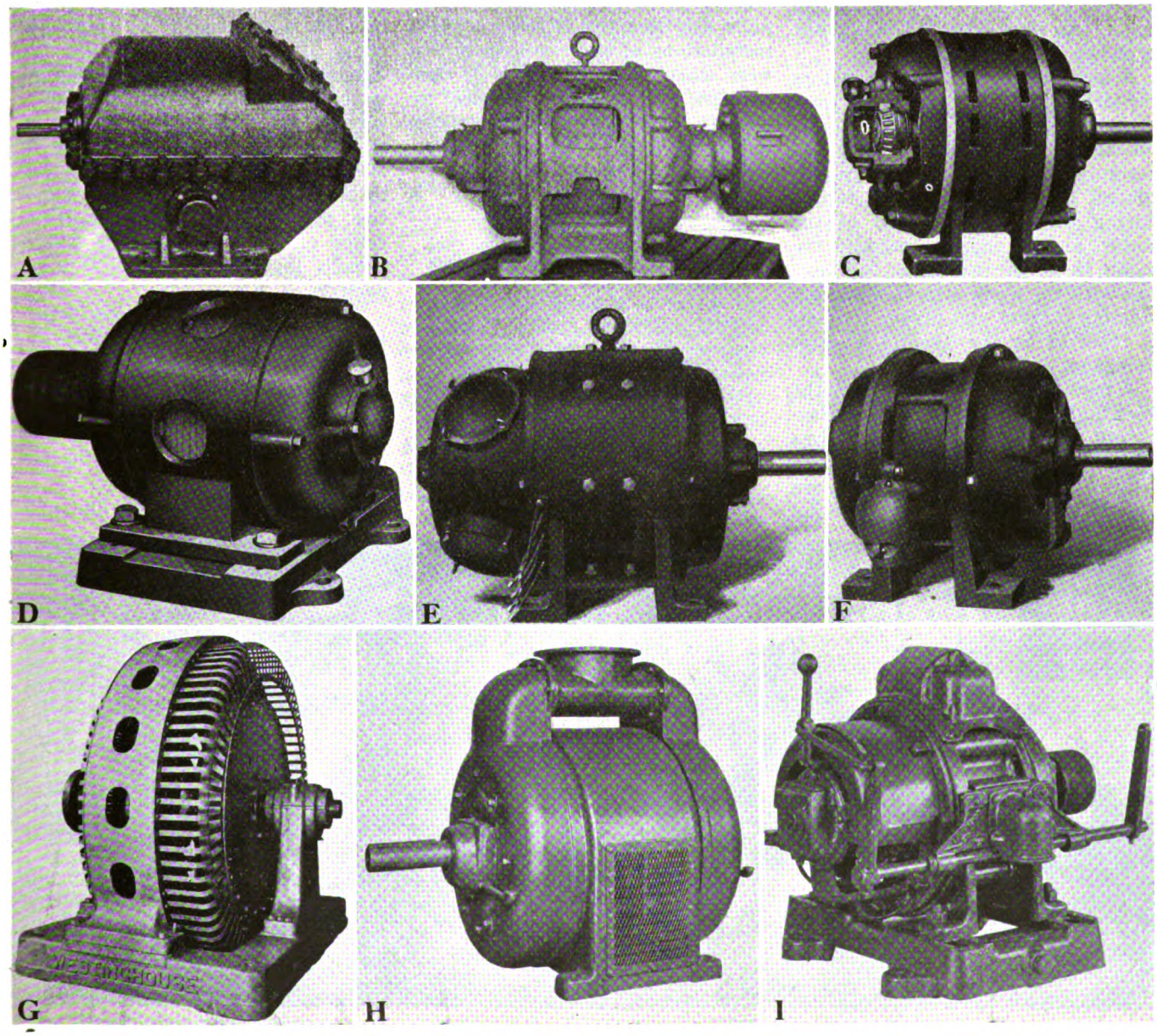
A new line of single-phase, adjustable varying speed, brush-shifting motors, having a 2½ to 1 speed range with constant torque load is announced by the General Electric Company.

Single-phase motor development also included a line of varying-speed, repulsion motors designed primarily for direct connection to slow speed exhaust fans. These motors are totally enclosed and are said to have the characteristics of a series motor which are desirable for a fan load. This development has been made by the General Electric Company.

The U. S. Electrical Manufacturing Company of Los Angeles, Cal., which has heretofore confined itself more or less to the Western market, is now shipping its motors east by way of the Panama Canal and is thus able to compete with Eastern manufacturers. This company makes a double-cage, polyphase, ball-bearing motor which is said to dispense with a compensator for starting.

New developments that have been made in motors to fit special requirements of industrial users.

These motors have been designed for the purpose of giving better protection from dust and gaseous atmospheres, for special starting conditions, to give lessened bearing maintenance, or to fit new variable-speed applications. At *A* is shown a General Electric 5-hp. gasoline fume-proof, direct-current motor which is said to cause no danger of explosion in a gasoline atmosphere. At *B* is shown a Westinghouse induction motor with the slip rings totally enclosed. This motor was designed for oil-well operation. *C* is the new tapered roller-bearing equipped motor made by the Howell Electric Motors Company, Howell, Mich. At *D* is shown the new ball-bearing equipped squirrel cage motor developed by The Linzee Electric Motor Company of Mansfield, Ohio. *E* shows the new water-tight, dust-tight, ball-bearing equipped, direct-current motor developed by the Reliance Electric & Engineering Company, Cleveland, Ohio. *F* is the type AA, alternating-current motor, made by the same company and which is now equipped with ball bearings. At *G* is shown a Westinghouse synchronous motor, having a built-in magnetic clutch so as to permit the motor to start heavy loads with a starting torque available up to the pull-out torque of the motor. *H* is a 440-volt induction motor that was designed for operation in an atmosphere of one-half of one per cent acetone. Pure air from outdoors is piped in through the top and discharged from the sides of the stator frame. This motor was made by the General Electric Company. At *I* is shown a new single-phase, adjustable varying speed, brush-shifting motor, having a 2½ to 1 speed range. It is also made by the General Electric Company.



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The usual squirrel-cage motor is a low reactance machine and has either a low or high resistance rotor winding. A new line has been designed by the General Electric Company having high reactance and either a low resistance or high resistance rotor winding, depending upon the application requirements. Such motors are applied quite extensively in the smaller sizes to refrigerating machines and in the larger sizes for driving pumps and other power station auxiliaries. They are thrown directly on the line without any starter to reduce the voltage.

Synchronous Motors.—The Allis-Chalmers Manufacturing Company states that in response to the demand for small synchronous motors having a speed of 1800 r.p.m., it has developed a self-excited revolving armature type of machine. These machines are said to develop quite a high starting and pull-in torque and are well suited for centrifugal pump drive. An illustration of this motor is shown in this article.

A new line of synchronous motors for driving air and ammonia compressors that uses a new type squirrel-cage winding which permits the designing engineers to have greater control of the current and torque during the starting period of the motor, and in addition permits the motor to be thrown on at full voltage with the assurance of minimum starting current and proper torques, is reported by the General Electric Company.

A motor has been developed by the Westinghouse Electric & Manufacturing Company for use in drives where the advantageous characteristics of the synchronous motor are desirable and where high starting torque with low starting current is essential. The motor is a combination of a standard synchronous motor with a standard magnetic clutch arranged so as to form a compact unit. This permits the motor to start heavy loads with starting torque available up to the pull-out torque of the motor. The manufacturer states that the motor has the advantage of pull-out starting torque, with low starting current, combining these advantages with simple, rugged construction, high efficiency and the desirable power-factor characteristics of standard synchronous motors.

Industrial Motor Drives

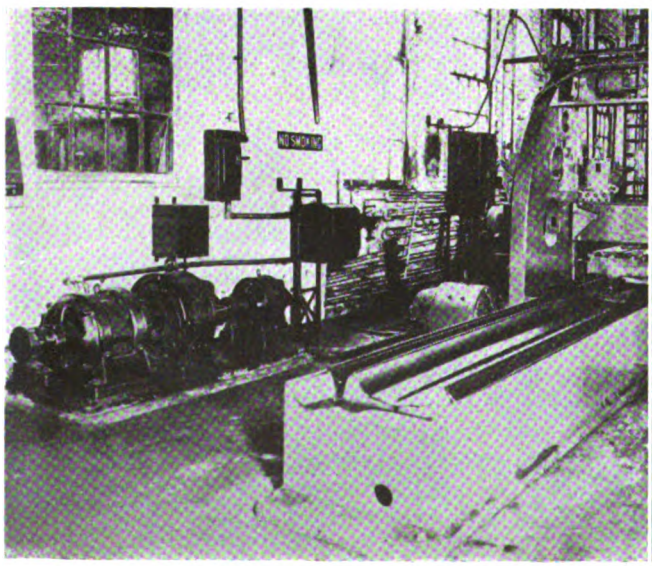
Steel Mills.—The most noteworthy feature of the electrification of steel mills has been the large number of installations of new equipment that were started during a year of comparative dull times for the steel industry. This fact is a most striking indication of the economy and reliability of electric operation.

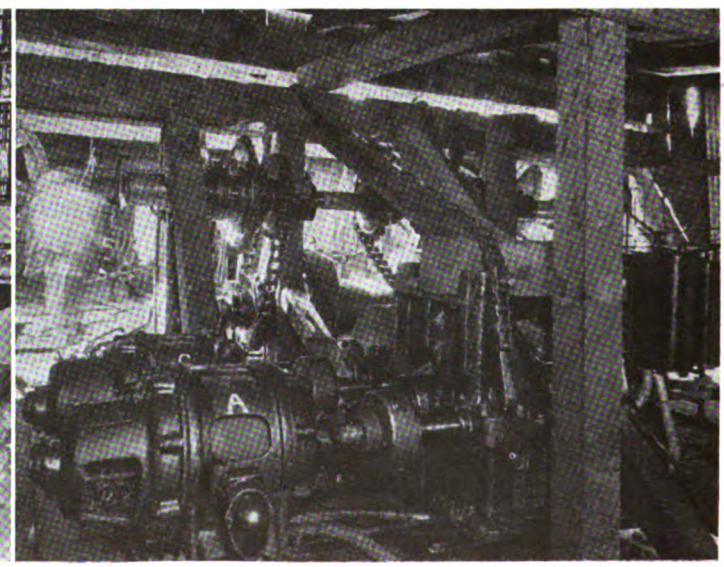
The Westinghouse Electric & Manufacturing Company report that five reversing equipments have been sold, including two large reversing blooming mills, two roughing structural mills and one finishing structural mill. This company further states that one of the greatest advances in the art was made this year when the company placed in operation a 5,000-hp., single-unit, reversing motor, which receives its power from two 2,100-kw. generators operating in parallel. It has heretofore been considered necessary to drive one motor from a single generator, and if two motors were used, two generators were required. By this new arrangement, it is said to be possible to design both motors and generators to best meet their operating conditions, rather than to have the design determined by the number of units of which the equipment is composed.

A 40-in. and a 44-in. blooming mill are each being equipped with 7,000-hp., single-unit motors by this company. These are said to be the largest single unit, direct-current motors ever built. A 500-hp., direct-current motor is being installed by this company to operate at 155 to 500 r.p.m., at any voltage from 220 to 250. This application is for a tire mill and constitutes a speed range of 3.7 to 1, which is exceptionally high for motors of this capacity.

The Allis-Chalmers Manufacturing Company of Milwaukee, Wis., reports that it has installed and put in successful operation three mill-type synchronous motors on main roll drives of steel mills. The motors are coupled to the mills without the use of a clutch.

By the addition of 45,350 hp. (nor-

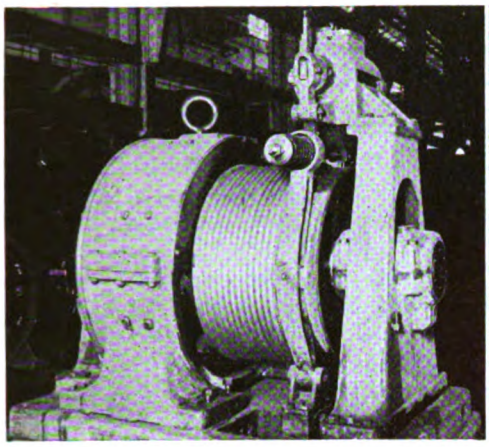


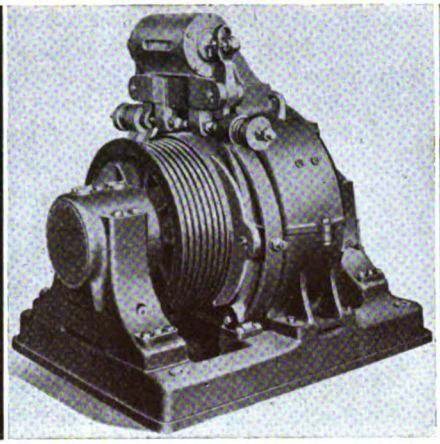


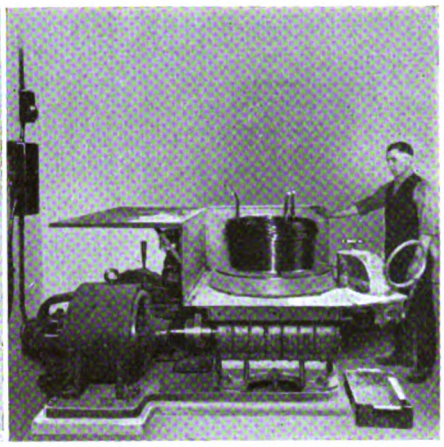
Two motor drive applications that are said to have greatly increased production.

At the left is shown a new variable-voltage, reversing, planer equipment that has been developed by the Westinghouse Electric & Manufacturing Co. The motor-generator set supplying the variable-voltage power can be seen at the left of the illustration. It is pointed out that this equipment gives a greater speed range, smoother acceleration and braking, combined with a power saving over the equipment previously made by this company. At the right is shown a differential drive for oil-well drilling that has been developed by the same company. Details of this drive are given in the accompanying article.

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Three motor drives that were designed to fit the user's special requirements.

At the left is shown a new gearless, traction elevator motor built by the Allis-Chalmers Manufacturing Company. This is a slow-speed, shunt-wound motor, the armature shaft of which is coupled direct to the hoisting drum. In the middle illustration is shown a special, variable-speed motor application made by the Reliance Electric & Engineering Company of Cleveland, Ohio, to a wire-drawing machine. It is said that increased production is obtained with this individual drive arrangement. At the right is shown a log carriage drive developed by the Westinghouse Electric & Manufacturing Company. The motor shown is rated at 35 hp. with a speed range of 10 to 80 r.p.m. and is supplied with variable-voltage, direct-current power from a 30-kw., motor-generator set.

mal continuous rating) of main roll motors during the year, the total of General Electric main roll drives has been brought to over 700,000 hp. This company reports that an installation of particular interest is a 14-in. continuous merchant mill at the plant of the Jones & Laughlin Steel Corporation. The nine stands of this mill are driven by seven, adjustable-speed, direct-current motors. This mill will roll a very large tonnage of diversified products and the employment of individual drives with a very wide speed range is said to enable it to do the work of two or three less flexible mills.

The 26-in. rail mill at the Sparrows Point Plant of the Bethlehem Steel Company was changed over from steam to electric drive by the installation of two 3,000-hp., 500-r.p.m., 660-volt constant-speed, induction motors made by the General Electric Company.

The Reliance Electric & Engineering Company reports that one of its most important application developments is an individual wire block driven by an adjustable-speed, d.c. motor with special automatic control equipment.

Textile Mills.—An application of the brush-shifting motor to the operation of textile finishing machinery (where the operation of several motors in tandem may be required) is reported by the General Electric Company. In each case the speed of the main motor is controlled by push buttons through the operation of a pilot motor, which actuates the brush-shifting mechanism, while the speed of the other motor is controlled either mechanically or electrically by the motion of a compensating gate or floating roll between sections of the machinery.

Rubber Mills.—The Westinghouse Electric & Manufacturing Company reports that for the past two years, its mill drive using synchronous motors without clutches or brakes has proven highly satisfactory. This is said to be due to the use of dynamic braking as a means of making safety stops, which has proven thoroughly reliable and effective. During the past year, further improvements and developments in the control have been with the view of obtaining even greater reliability and quicker stopping. This company states that the development of a three-pole, double-throw, gravity-operated contactor makes it possible to use dynamic braking with either manual or automatic starters, the braking feature being entirely independent of any external control circuit or relay operation.

The elimination of the use of low-voltage and other relays in the braking circuit, together with the use of gravity operation is said to give a reliability exactly comparable to direct-current drive for calenders, which has been in use for so many years.

Lumber and Woodworking Mills.—A variable-voltage, log carriage, consisting of a d.c. motor and motor-generator set, has recently been installed on the Pacific Coast by the Westinghouse Electric & Manufacturing Co. The motor is rated at 35 hp., and has a speed range of from 10 to 80 r.p.m. Power is supplied by a 30-kw., 320-volt motor-generator set.

The General Electric Company reports that small, drawn shell type motors of unusual speed were provided for the operation of woodworking machinery. A typical application of this character consists of five small motors with operating speeds of 25,200 r.p.m., which are utilized by a single woodworking machine, the current for the small high speed motors being supplied by means of a frequency changer. The motors operate on three-phase, 240-volt, 420-cycle circuits.

Paper Mills.—A new rotary contactor regulator for sectional paper-machine drive, that is an improvement over past apparatus in that great simplicity and a more flexible action is obtained, is reported by the Westinghouse Electric & Manufacturing Company.

A paper winder drive with automatic regenerative tension control for sheets and including automatic regenerative and dynamic braking for the winder and unwinder has been placed in operation by the same company. This is said to permit much faster operation of the winder and much better control of the finished roll, as it produces a uniform tightness throughout. The expense and annoyance of frequent replacement of friction brake linings on the unwinding roll is thus avoided.

Automatic speed regulation of the vibrating regulator type for single motor paper machine drive has been developed and placed in operation by the Westinghouse Electric & Manufacturing Company. The use of this device is said to make possible a degree of regulation not previously obtainable through inherent speed regulation characteristics of the motor and generator. This is a decided advance in the art and contributes in a marked degree toward precision control, which is becoming of greater

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and greater importance in this industry.

An installation of a sectional paper-machine drive, for a 175-in., 1,000-ft. per min., Kraft paper machine, has been placed in operation by this company. This is the largest Kraft paper machine built to date.

An installation of five automatic grinder, load regulators for the control of as many 1,800-hp. synchronous motors driving pulp grinders has been placed in operation by this company. The control of the load on these machines is said to relieve the governors of the power plant of an enormous amount of work and to greatly improve the frequency and voltage regulation of the entire system.

Industrial Haulage. — Induction motors designed to give a high starting torque with a relatively low current and a high efficiency when operating under load were applied for the first time to large systems of conveyors by the General Electric Company.

The first haulage electrification of an open-pit iron mine in America was effected by the adoption of three 60-ton double truck, 500-volt mine locomotives made by the General Electric Company at a mine of the M. A. Hanna Mining Company at Duluth, Minn. These locomotives are provided with auxiliary cable reels, and current supply is effected by means of an overhead trolley.

Machine Shops.—With the improvement in cutting tools and improved quality of rails has come a demand for more driving power for frog and switch planers. During the past year the Reliance Electric & Engineering Company has developed and applied motors in sizes up to 100 hp., 250-1,000 r.p.m. to such planer drives. This company further states that reversing motor drive with automatic control of such work means the elimination of belt troubles, ample power, accurate speed adjustments for a cutting speed range of 1 to 2, and a separate speed adjustment for return strokes from 50 to 100 ft. per min. Quick return strokes reduce the non-productive operating time to one-third that of belt drive.

A complete line of variable-voltage, reversing planer equipments has been developed by the Westinghouse Electric & Manufacturing Company. Each unit makes use of a separate motor-generator set; consequently, it is possible to install a variable-voltage equipment on a planer at any point in a plant having alternating-current service. Other outstanding features that this drive is said to have are a greater speed range, smoother acceleration and braking, and very simple control, combined with a power saving in service where reversals are frequent.

Elevators.—The General Electric Company reports that radical improvements were made in the operating characteristics of its high-speed elevator outfits. One of the principal difficulties in the past has been that the speed, on any one speed position of the controller, is decidedly variable with the load, being slowest when the motor is hoisting the maximum load and fastest when the motor is being overhauled by the load. The improved system consists of a motor and motor-generator controlled on the Ward Leonard principle but with the novel feature of an auxiliary series generator by which a considerable degree of compounding can be successfully applied to the main generator to an extent entirely impracticable to apply in the ordinary manner.

A new gearless traction elevator motor for passenger service has been developed by the Allis-Chalmers Manufacturing Company. It is of the shunt-wound type designed for operation at slow speeds suitable for giving normal car speeds, using standard diameter sheaves. The system of control used is the Ward-Leonard requiring separate motor-generator set and variable-voltage control.

Elevator equipment and the necessary control has been developed to such a point of perfection that speeds of 1,000 ft. per min. are now entirely possible, is reported by the Westinghouse Electric and Manufacturing Company. In fact, there seems to be no reason why speeds cannot be increased up to the limit prescribed by the speed at which humans can be transported vertically without discomfort.

Oil Wells. — The Westinghouse Electric & Manufacturing Company reports that field tests of the Hild differential drive for oil wells have been made. Two holes, 3,700 ft. deep are said to have been completed successfully.

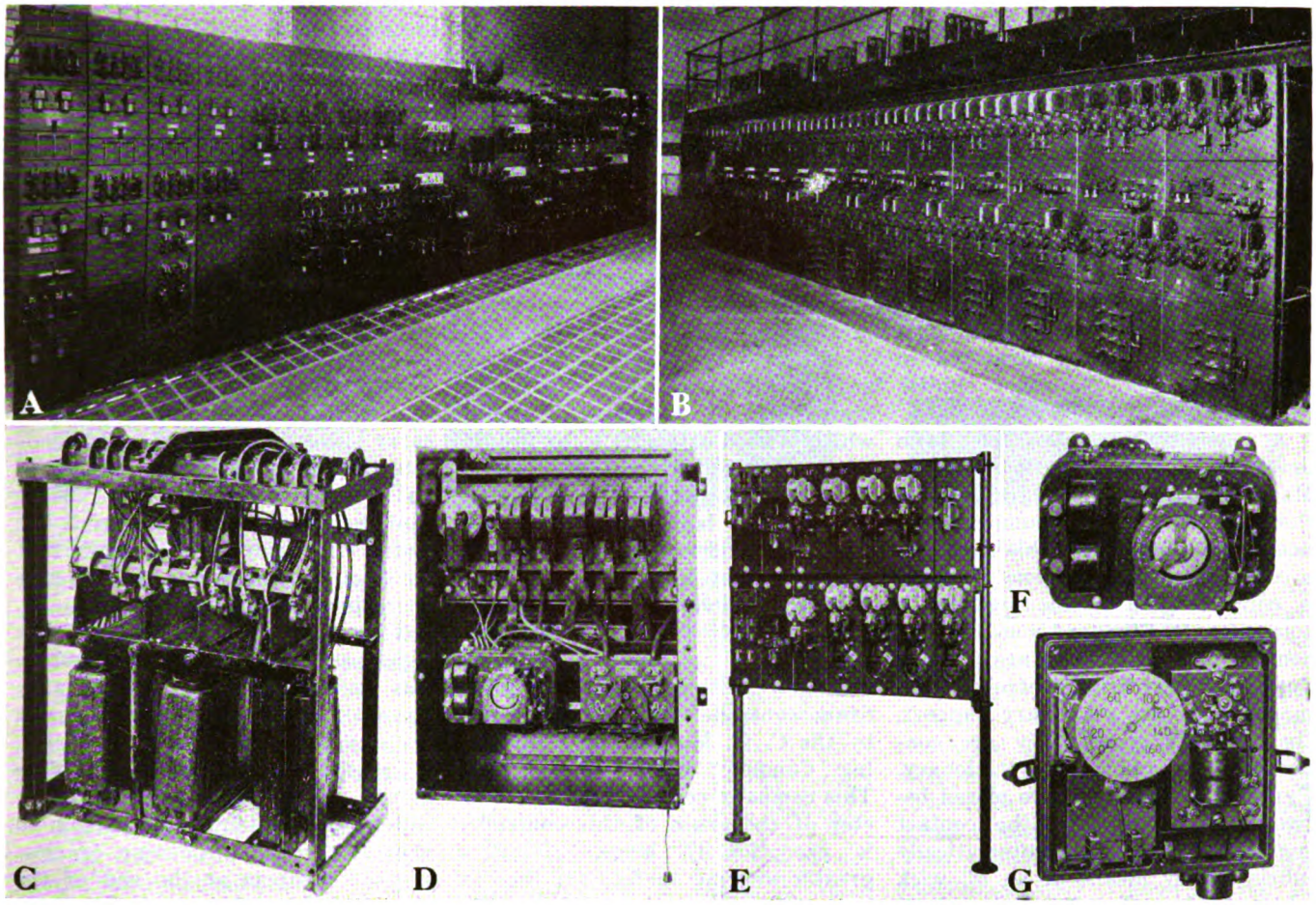
This drive is designed primarily for rotary drilling. Its function is the automatic regulation of the downward bit feed according to the resistance of the formation encountered. Essentially, it consists of a differential gear unit, two slip-ring motors, and a rotary drawworks. One of the motors—the drill motor—drives the rotary table which revolves the drill pipe and at the same time drives one-half of the differential. The other—the regulating motor—drives the other half of the differential. The two motors operate the differential in opposite directions, the operating motor in a direction tending to raise the drill pipe and the drilling motor in a direction tending to lower it. By adjusting the speed of the drilling motor slightly higher than that of the regulating motor, a slow downward feed of the drill pipe is produced. If the resistance to the drill is increased due to change in formation, the increased load slows down the drill motor and a slower feed results. Conversely, a lighter load means a more rapid feeding of the bit. High resistance encountered in drilling through hard rock causes the bit to rise until it clears itself.

Motor Control Equipment

Automatic Controllers. — Because of the very nature of industry and the years of study of application and performance of motor devices and control, there is always a certain amount of development and refinement in controller design and construction that is accomplished through the increased knowledge of the requirements of industrial power drives. The year 1924 has been no exception in showing progress and developments.

One of the outstanding developments is the inductive, time-limit controller devised by The Cutler-Hammer Manufacturing Company of Milwaukee, Wis. In the design of this time-limit starter the inductive principle is utilized to obtain the accelerating time, a transformer being used in place of relays, interlocks, dashpots or other moving parts to control the time of acceleration. The manufacturer states that through the medium of the transformer, a holding-out current of transient nature is obtained in successive accelerating switches. Transfer of connections takes place automatically with the cutting out of successive steps of resistance without disconnection of the coil circuits. It is said that in this new development, the ac-

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celeration period is very uniform under ordinary conditions of load variations, the time being somewhat increased on heavy loads; thus the machine driven, whether reversing table, screw-down or other auxiliary machine, is always brought up to speed in the same period to insure the productive synchronism and plant efficiency desired.

Another development in time-limit acceleration is reported by the General Electric Company in the case of a 300-hp., a.c. motor on the hoist and a 75-hp., a.c. motor on the trolley of a coal tower at Clairton, Pa. Current-limit acceleration was previously used on this application and the change to time-limit acceleration was secured by using a suitable number of direct-current contactors and allowing them to close in sequence, each one being interlocked through the preceding contactor. Direct-current contactors were used to secure a slow time of closing, so that fewer contact elements were required than would have been necessary with alternating-current contactors. No time element relays were used.

Two forms of resistor-type magnetic starters for alternating-current motors have been produced by the General Electric Company; one for squirrel-cage induction motors, and one for slip-ring motors. Mechanically these starters are very much alike, their difference being chiefly in the connections. They both employ a new type of time-element relay for the accelerating period, which can be adjusted to about six seconds. The relay consists of an armature that is drawn across the face of an a.c. magnet by a spring which is distended when the line contactor closes. The magnetism resulting from the alternating current intermittently attracts and releases the armature as it slides by the pole face, thus giving the desired time-adjustment.

A great advance has been made in the control of blooming mill auxiliaries, by the installation of two entirely separate control circuits, either of which can be used at will, is the report received from the Westinghouse Electric & Manufacturing Company. Each master switch is plugged into a receptacle, and in case of trouble can quickly be replaced by a spare. A complete spare control panel is included which can be quickly transferred to any motor.

Similar information comes from the Rowan Controller Company of

New controllers and new methods of installing them that are securing more flexible and convenient operation for industrial users.

At *A* is shown an installation of Allen-Bradley, automatic, resistor-type starters in the plant of the Fisher Body Corporation at Cleveland, Ohio. Twenty-six motors are controlled from a central location by means of this arrangement of control panels. In illustration *B* is shown the auxiliary control board made by the Westinghouse Electric & Manufacturing Company for the control of the auxiliaries of a 40-in. blooming mill. One of the features of this installation lies in the use of double-throw switches in the bottom sections of the boards by means of which a spare panel may be quickly transferred to any motor. At *C* is shown a new automatic compensator developed for use on potentials of 2,500 volts and less by the Electric Controller & Manufacturing Company of Cleveland, Ohio. This compensator is tightly enclosed and designed for either indoor or outdoor service. In illustration *D* is shown a new automatic compensator that has been developed by the General Electric Company for remote control of squirrel-cage motors driving lineshafting, pumps, compressors, conveyors, and the like. At *E* is shown the new inductive, time-limit, automatic controller that has been brought out by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis. The outstanding feature of this controller lies in the use of an inductive relay to secure the time element required in accelerating the motor. In *F* is shown the new definite-time, accelerating relay developed by the General Electric Company. One application of this relay is shown in the compensator in illustration *D*. *G* is a pressure governor developed by the same company. It is intended for use in starting or stopping the control for air compressors or other devices requiring pressure regulation. Further details concerning the equipment illustrated at *A*, *B*, *E*, and *F* are given on pages 76, 77 and 78. More complete descriptions of the apparatus shown at *C*, *D*, and *G* are given on page 79.

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Baltimore, Md., in citing the case of a switchboard containing the necessary control equipment for the auxiliaries for a large blooming mill in the Cleveland steel district. This control is shown in one of the accompanying illustrations. A unique feature of this installation is that all the controllers for the front and rear tables and the screw-down are exactly alike. An additional spare control panel is provided so that by means of throwover switches this spare can be rapidly connected in place of any of the other similar controllers.

A new type master has been developed by the Cutler-Hammer Manufacturing Company for use particularly with Cutler-Hammer magnetic-type controllers. This master is a compactly enclosed structure with a contact cylinder mounted on a square shaft. Standard non-stubbing contact fingers such as are used in Cutler-Hammer drum controllers, are mounted on the stationary support, the leads to which they are connected also remaining stationary. Pyroplax arc barriers are placed between the fingers and the contact segments which are automatically lubricated by means of an oil wick which holds sufficient oil for about six months use.

A new automatic reversing planer controller has been developed by this company. The scheme of control employed plugs the planer motor in stopping and reversing the planer, as the company reports that this results in the fastest method of operation. Two shunt-field rheostats are provided in the control—one is for regulating the cutting speed and the other is for adjusting the return stroke speed.

For several years past it has been evident that the trend of safety regulations is toward the enclosure of all types of motor starters and speed controllers. During the year, the General Electric Company reports that work along these lines was practically completed, and the remaining open-type starters and speed controllers were provided with either self-contained enclosing cases with external handle or were redesigned to accommodate enclosing cases when required.

Monitor Thermaload starters, manufactured by the Monitor Controller Company, Baltimore, Md., are now being built with standard Monitor side-arm contactors instead of the special contactor previously employed. Hairpin-shaped thermal elements are also being supplied, instead of the coiled elements previously used.

The thermal relay of the Monitor Thermaload starter operates on the thermal expansion principle. The heat produced by the thermal element under overload causes a liquid confined in a tubular receptacle to expand and to elongate two expansion units. These expansion units in turn operate an arm containing two contacts which control the operating circuit of the contactor. The liquid used is carbon tetra-chloride, a non-corrosive and non-freezing liquid which is used extensively for fire extinguishing purposes. This starter is intended for starting small induction motors, both single-phase and polyphase, and is said to protect the motor against light overloads dangerously prolonged, yet permits the motor to carry heavy overloads momentarily.

A new steel enclosed, dust-proof drum controller is being marketed by the C. H. McCullough Engineering Company of Pittsburgh, Pa. This company reports that the diameter of the drum of this controller is exceptionally large, giving a greater wearing surface and thereby increasing the arcing distance between points. This company also points out that due to its dustproof qualities the controller is especially adapted to foundries, steel works, cement plants and similar dusty locations.

The Condit Electrical Manufacturing Company informs us that during the past year it has arranged its type N-3 oil motor starters for push button control, thus making them especially adaptable to industrial service. The type N-4 starter which was developed in 1923 is now equipped with thermal cutouts.

During the past year the Allen-Bradley Company of Milwaukee, Wis., has added refinements to its lines of across-the-line starters, automatic starters, and semi-automatic starters according to reports received from this company. It also informs us that these lines have been standardized so that they can be made on a large quantity basis at a very reasonable price and yet keep the same standard of quality for which these starters have been noted.

Heretofore, fractional horsepower motors have, to a very large extent, utilized standard, wiring device switches, which were primarily designed for lighting circuits. A new design of single-pole and double-pole enclosed tumbler switches, assembled in boxes for conduit wiring, for throwing small motors on the line, now gives these motors a class of control equipment comparable with that provided for large motors, is the report received from the General Electric Company.

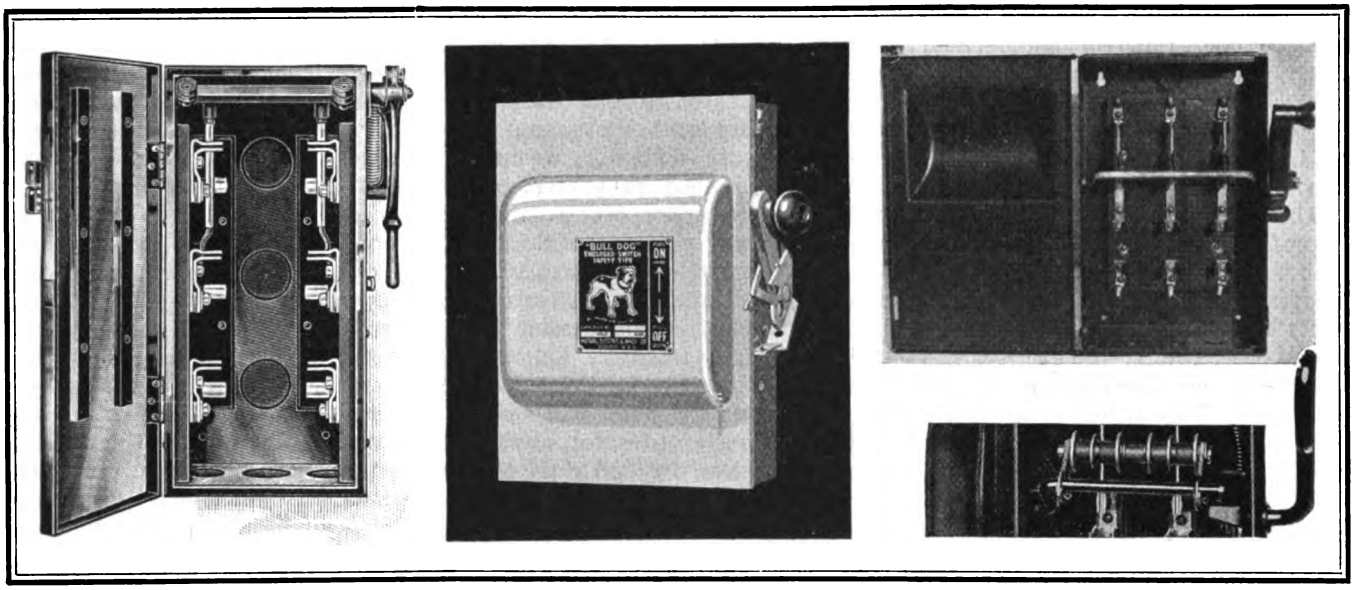
This company also informs us that a new thermal overload relay was designed to follow the heating and cooling curve of the average induction motor, and is particularly adapted to service where it is important that the motor be permitted to carry heavy, short-time overloads intermittently, without being tripped out by the overload device. It is said that this device will permit the motor to do any kind of work that does not run the motor above a safe operating temperature.

This company states that it has developed a definite time relay which was utilized for the first time in an automatic compensator, and is used to provide the accelerating period. It consists essentially of a motor-driven train of gears, magnetic clutch, and switching mechanism to provide for either opening or closing the contacts at the end of the time for which the device is set. It is adjustable from a few seconds up to several minutes, and is adaptable to many applications where a definite time adjustment is needed.

The Cutler-Hammer Manufacturing Company states that a complete line of control equipment was brought out in 1924 for various sizes of Fynn-Weichsel, alternating-current motors (made by the Wagner Electric Corporation, St. Louis, Mo.). For the smaller sizes the face-plate type is used with the operating handle arranged for manipulating from the exterior of the enclosing case. A drum type starter is used with the larger motors and incorporates in its design non-stubbing fingers, a square steel shaft for carrying the contact segments, and blowout shields. In all of these starters the design takes care of simultaneously cutting out resistance in each of the two secondary windings found in this type of motor.

For the automatic control of motor-driven pumps, air compressors, and the like, the General Electric Company has developed a new pressure governor for use in connection with automatic starters. This governor is of the Bourdon tube type, and can be used on any liquid or gas system that will not corrode the

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Less maintenance and more reliable operation are the points featured in these new safety switches.

At the left is shown the new safety switch made by the Super-Safety Electric Company, Chicago, Ill. This switch is unusual in that the switch blades and jaws are mounted on the sides of the cabinet instead of on the base, thereby leaving the base clear for wiring. In the center is shown the new "Lumenized" finish, Bull Dog safety switch made by the Mutual Electric & Machine Company, Detroit, Michigan. This finish is said to resist rust, acids and alkalies. At the upper right is shown a new safety switch brought out by the Westinghouse Electric & Manufacturing Company. Special construction is said to have been used to secure durability. At the lower right is shown the new cross-bar construction developed by the Square D Company of Detroit, Mich. Improvements have been made in the insulation of the crossarm and the method of fastening it to the blades.

Bourdon tube. The equipment includes an "impulse" magnetically operated relay of a quick throwover type that breaks its own operating circuit as soon as it functions.

Three across-the-line automatic starters have been placed on the market by the Sundh Electric Company of Newark, N. J., one with undervoltage release or undervoltage protection, the second having, in addition, inverse-time-limit overload thermal relay protection and the third being provided with inverse-time-limit overload relay protection. All these starters are manufactured in either the open or inclosed type, two-pole or three-pole, for motors up to and including 10 hp., 220-440-550 volts.

This company's principal activities have heretofore been more or less confined to furnishing control for large office buildings and pump concerns. This company now plans to enter the industrial market more intensively with the present line of equipment rounded out with the additions that have just been described.

Compensators.—Two new automatic compensators have appeared on the market during the past year. One of these is a high-voltage compensator made by The Electric Controller & Manufacturing Company of Cleveland, Ohio. It is built for voltages of 2,500 and below, is push-button operated and entirely automatic. With the exception of the overload panel, which is mounted on the top of the tank, the compensator is entirely submerged in oil and the tank is so designed that the compensator is said to be dustproof, weatherproof, vaporproof and fireproof. It can be installed either indoors or outdoors.

The power supply for the push-button circuit comes from an independent low-voltage circuit which is taken from a separate transformer so that there is no danger of the operator ever coming into contact with the high-voltage circuit. The compensator is so designed that continuous torque is applied to the motor from the time the push button is pressed until the motor has been brought up to speed. This compensator is shown in an accompanying illustration.

A new automatic starting compensator, for squirrel-cage, induction motors, has been placed on the market by the General Electric Company. This motor starter is for remote control of constant-speed, two- or three-phase, squirrel-cage motors up to 600 volts for general applications driving lineshafting, pumps, compressors, blowers, conveyors, and the like. With it such equipment may be started or stopped from a distance by means of one or more small hand-operated push buttons or snap-switches located within convenient reach of the operator or automatically operated by a pressure governor, float switch, thermostat or the like.

Resistors.—A ribbon-type resistor, wound on edge, has recently been developed by the Monitor Controller Company, Baltimore, Md., and is intended for service where cast-iron grids would otherwise be employed. This resistor consists of a high-resistance alloy ribbon wound on edge in helical form and mounted on a steel-reinforced porcelain support which passes through the entire length of the unit, supporting and separating every convolution at two diametrically opposite points. This method of construction relieves the resistor ribbon from mechanical strain and permits of thorough ventilation. The maker states that the ribbon can operate at any temperature up to red heat without sagging or in any way injuring the resistor as a whole.

A system of terminals and taps enables a unit to be connected into a circuit, and to be interconnected with other units. Two simple forms of clamps provide all these facilities. These clamps may be placed at any desired point along the resistor and may be changed at will. This permits of accurate adjustment of the resistance steps. The maker reports that a saving of weight and space is obtained by the use of these resistors as compared to cast-iron resistors. These resistors are shown in an accompanying illustration.

The "EMB" grid resistor, which is manufactured abroad, is being introduced by the C. H. McCullough Engineering Company of Pittsburgh, Pa. This resistance is made of drawn material and is made in

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one continuous length for an amount equal to one frame or bank. The maker informs us that this resistance is unbreakable, rustless, scaleless, of uniform section, jointless in the frame and is covered by a 5-yr. guarantee. He also states that the weight of this resistance is less than that of cast-iron grids of the same rating.

Safety Switches.—A new small safety switch has been placed on the market by The Trumbull Electric Manufacturing Company of Plainville, Conn. This switch is now made in the 100-amp., 250-volt size and will shortly be made in the 440- and 550-volt size. The maker reports that the switch is characterized by its small size, yet the parts are accessible because the switch may be easily removed from the box. The switch is constructed on the double break principle, the blades being carried on a rotor made of molded material.

A new line of quick make, quick break enclosed safety switches has recently been put on the market by the Westinghouse Electric & Manufacturing Company. This line was designed to meet the demand for a simplified, enclosed switch without the full safety features.

This switch, known as the WK-60 switch, is unique in that the quick operating mechanism has been condensed to a few simplified parts and located inside the operating handle. The maker states that this feature alone is a marked advance in the design of safety switches, since this construction will lend greater reliability, lessen maintenance cost, and at the same time, make it easier for plant operating men to inspect, test and make repairs.

A new "Lumenized" finish has been added to the line of Bull Dog safety switches made by the Mutual Electric & Machine Company of Detroit, Mich. The company states that this finish involves the depositing of aluminum flakes, like minute fish scales, upon the basic metal under high temperature. It is said that this results in giving the switch the following qualities: luminous in the dark; resists rust, acids, and alkalies; easily grounded; and is the last word in cleanliness.

A new type of cross-bar construction has been incorporated in the safety switches made by the Square D Company of Detroit, Mich. A steel bar is heavily insulated with molded composition tubes, which not only possess superior mechanical strength but greater dielectric strength as well. It has an extremely low absorption of moisture, which is said to prevent warping and the consequent distortion of blade alignment. Wide fibre washers have been provided to prevent accumulation or adherence of dust, breaking up any continuous path of dust to ground. The insulating tubes have an offset at the ends so that dust cannot work in under the washers, causing leakage.

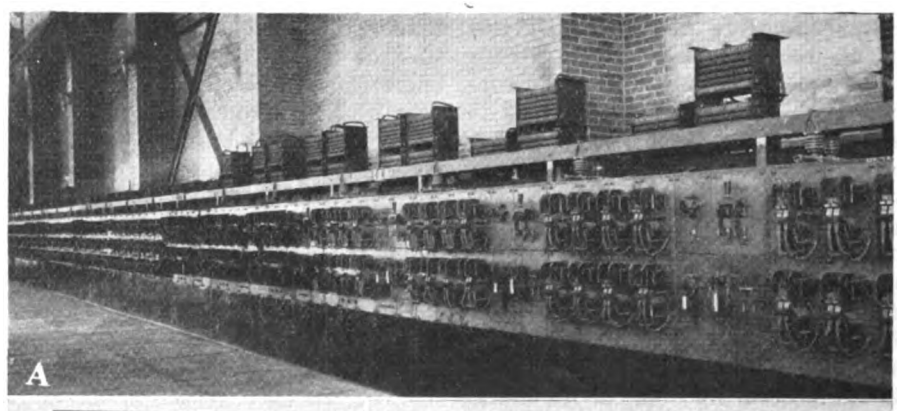
During the past year the Super-Safety Electric Company has developed a new design of safety switch in the larger sizes. Instead of the contacts being on the base of the cabinet as is usual, they are placed on sides of the cabinet, thus leaving the base entirely clear. This constitutes the principal difference between this switch and the more usual types of safety switches.

The maker reports that this type of construction results in the following advantages: greatly increased wiring space within the switch and at the same time a reduction in overall dimensions; double break—a break on each side of the fuse; greater flashover distance between polarities; and perfect and even contact between all contact members by reason of their tandem arrangement and their self-aligning construction. This switch is shown in one of the accompanying illustrations.

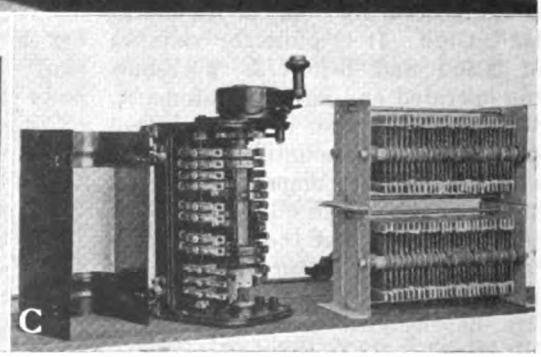
Limit Switches.—A new safety limit stop has been developed by The Morgan Engineering Company of Alliance, Ohio. As shown in an accompanying illustration this device consists of a cast-iron box in which are mounted two double-throw, single-pole switches. These two switches when actuated by contact with the hook block cause the limit switch to function. The maker states that this limit switch differs from others in that a resistance is thrown in series with the armature as the limit switch starts to function, thereby slowing down the armature and greatly reducing the amount of current broken by the contactors. Complete stopping of the hoist motor is accomplished by the usual arrangement of dynamic braking. The maker points out that another feature of this limit switch is that the lowering circuits are established immediately upon the reversal of the controller, through the action of a solenoid; there is no waiting to lower through resistance. Other features pointed out by the manufacturer are: no external banks of resistance, for the limit switch is

How to insure continuous operation is a problem before every electrical superintendent.

At *A* this problem has been solved by providing a spare controller that may be quickly connected in place of an inoperative panel by means of throw-over switches. These controllers were built by the Rowan Controller Company of Baltimore, Md., and are installed in a blooming mill for the control of the auxiliary motors. At *B* is shown the new Thermaload starter made by the Monitor Controller Company of Baltimore, Md. This controller is equipped with a new thermal overload relay. *C* is a new drum-type starter developed by the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., for the control of the Fynn-Weichsel motor made by the Wagner Electric Corp.







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self-contained; positive in action, for an upward movement of the weight of even a fraction of an inch will actuate the limit stop; the switch is foolproof, having only one adjustment; extra large copper to carbon contactors are used; only one swinging weight is used, this being guided by one of the hoisting ropes; and the sequence of operation of the contactors is obtained by a single system of levers, no cams, springs or counterweights being used.

The Cutler-Hammer Manufacturing Company of Milwaukee, Wis., reports a new development in safety limit stops which is said to be a compact, rugged unit with a number of features which are so important in the functioning of a safety device. The working parts are liberally designed and arranged to move freely; this ease of operation being still further insured by the provision of ball bearings.

Miscellaneous.—A new quick-acting, electric solenoid brake has been developed by the Whiting Corporation of Harvey, Ill. This brake was especially designed for crane service application.

The maker points out that the brake arms are so pivoted that the shoes release equally at all points; there is no chance, therefore, of the shoes dragging at the lower ends. This is said to be a big advantage in applying the brake as the shoes bear equally at all points, resulting in quick braking action and uniform wear.

Improvements in its electro magnetic sander are reported by Nichols-Lintern Company of Cleveland, Ohio. An electrically-heated chamber has been placed around the sand box, thus keeping the sand warm and dry, thereby greatly increasing the efficiency of the sander. These sanders are intended to replace dangerous and wasteful hand sanding methods and are said to save crane and runway maintenance.

The use of static condensers for power-factor correction in industrial plants has increased considerably. The Westinghouse Electric & Manufacturing Company reports that it has developed a new low-voltage unit that may be connected at the motor or place where the power is used, thereby reducing the line losses in the feeder circuits. This new line of low-voltage condensers is made for 220-, 440-, and 550-volt, 60-cycle service. This condenser is shown in one of the accompanying illustrations.

The National Electric Condenser Company of New Haven, Conn., is also putting out a line of low-voltage condensers for connection direct at the motor terminals.

Control devices designed to give safer and more reliable operation of motors.

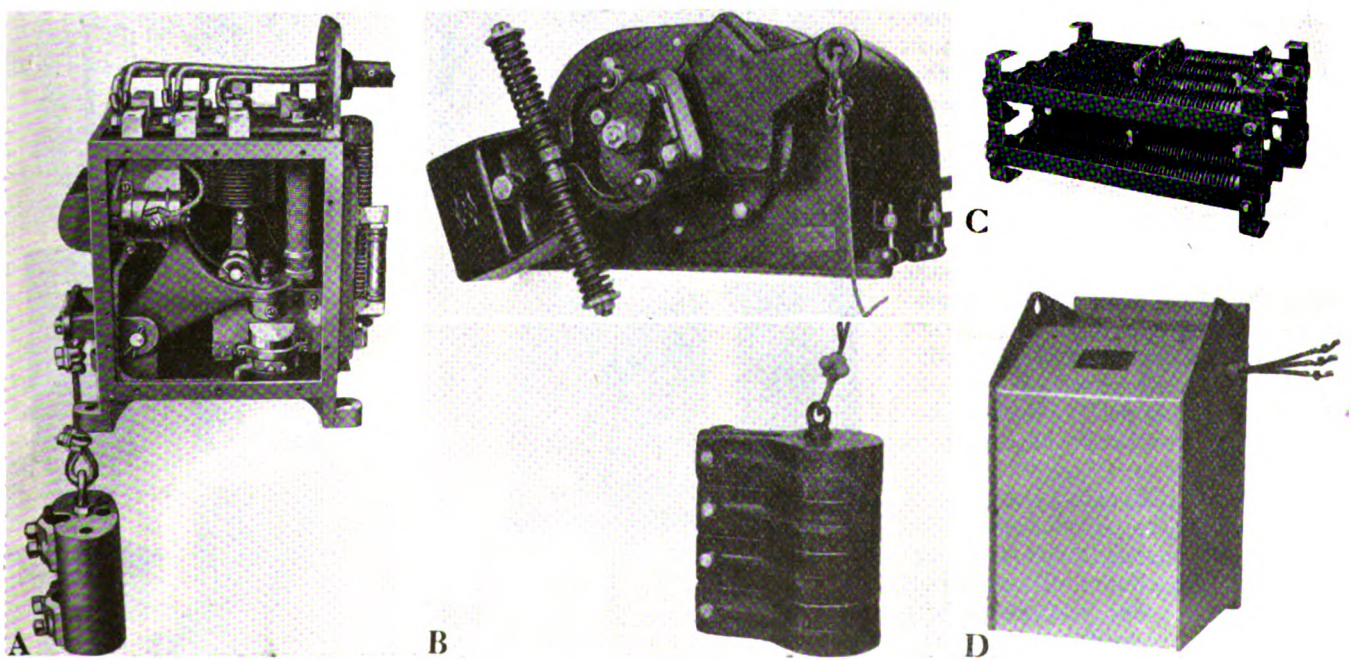
At *A* is shown the new, crane hoist, limit stop developed by the Morgan Engineering Company of Alliance, Ohio. It is pointed out that very little arcing results at its contacts during operation. *B* is a new limit stop developed by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis. At *C* is shown a new resistor made by the Monitor Controller Company, Baltimore, Md. It is said to be unbreakable, very compact and light in weight, although designed for heavy-current service. *D* is a static condenser designed for connection directly at the terminals of the motor, so as to correct the motor power factor at the motor instead of in the substation and thus lighten the load on the feeder cables.

Industrial Substation Equipment

Automatic Substations.—The automatic station has become firmly established as an economic and operating necessity in the electrical industry. With its inherent advantages established beyond dispute a marked advance in the application of this type of control was made during 1924.

There were no radical changes in the design of automatic switching equipments. The tendency during 1924 was to produce unit equipments which are easily handled and installed and to standardize wherever possible. The General Electric Company reports that standardization has progressed to such an extent that complete automatic stations for mining and industrial service are now being stocked.

To meet the requirements for this class of service, the General Electric Company states that one type of standardized design is so arranged that a single machine, automatic control equipment may be used in either a single- or multiple-unit station with any number of reclosing feeders, thus giving maximum flexibility since it allows the arrangement of converting units in any desired manner with a possibility of later re-arrangement if called for by a change in load conditions. This may then be accomplished without modifications of the control.



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Transformers.—The General Electric Company states that many detailed improvements have been made affecting both the construction and operation of transformers of various types. One of these consists of a scheme for bringing underground cables into the transformer without any exposed terminals or live parts. The underground cable is brought up into a compartment filled with fluid insulating compound. Suitable links and connectors are provided in this compartment so that the cable may be properly phased in. This compartment is connected by means of bushings, to an upper compartment which is kept filled with oil by means of a pipe leading to the main tank.

The Packard Electric Company of Warren, Ohio, reports that the designing of a complete new line of steel cases for distribution transformers has been completed. The use of cast-iron cases by this company has been discontinued, and all shipments are being made in the new cases.

The Westinghouse Electric & Manufacturing Company reports that during the past year, a transformer has been built mounted in a rectangular tank, so arranged that one side of the tank could be removed and the transformer rolled out on a track for inspection and repairs. This was necessary on account of the limited head room, preventing removal of the windings through the cover of the tank.

This company has also developed a new and improved type of breather designed to overcome the disadvantages of the usual form of calcium-chloride breather that has been in use for so many years. With this device, the calcium-chloride is placed in a screen basket suspended on a spring of large diameter. When loaded with the proper amount of calcium-chloride, the spring is depressed until a pointer stands at "fill to here." When in operation the breather picks up moisture, increasing the weight of the charge until the spring is depressed to the "refill" point. The design is such that the calcium-chloride will not become saturated before the refill point is reached.

The Gisholt Machine Company of Madison, Wis., reports that operating costs have been reduced in many applications of their direct-current transformers. The purpose of these transformers is to reduce 110 volts, direct current economically to the lower voltages required by master clocks, time stamps, cost recorders, signal bells, buzzers, annunciators, alarm systems, elevator bells and the like.

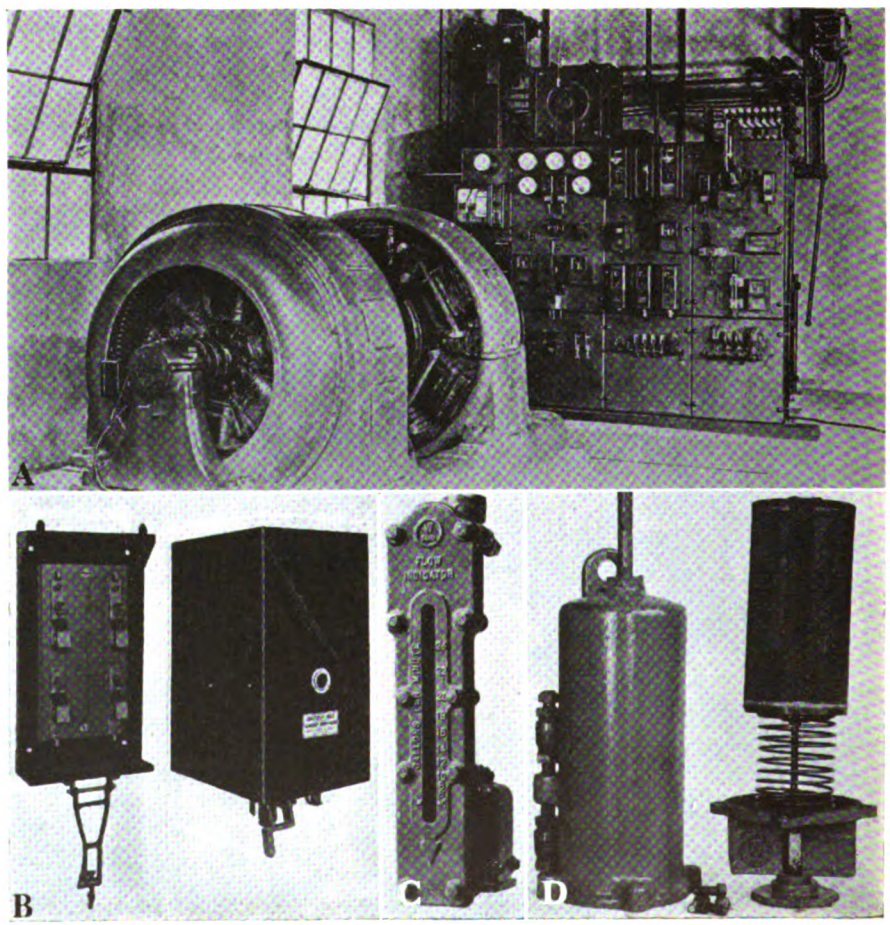
An improved design of flow indicator for use with water-cooled transformers has been brought out by the Westinghouse Electric & Manufacturing Company. The instrument may be used on either an open or closed water system, and operates without the use of moving mechanical parts. An indicator is used in each section of the cooling coils where more than one section is used, thus giving an opportunity to regulate and equalize the amount of water in each section.

Carbon Circuit Breakers.—Several new developments have appeared in carbon circuit breakers during the past year. A shock-proof circuit breaker has been developed by the Roller-Smith Company of New York. N. Y., and is recommended by them for installations where there are apt to be conditions of excessive mechanical vibration. A new double-pole, interlocked-trip circuit breaker has also been developed by this company and its outstanding characteristic is said to be in the fact that the two poles are closed independently and successively; the pole first closed will open as soon as the second pole is closed if an overload exists and both poles will open simultaneously on an overload. This type of breaker is intended for use on motor and feeder circuits in place of switches and fuses.

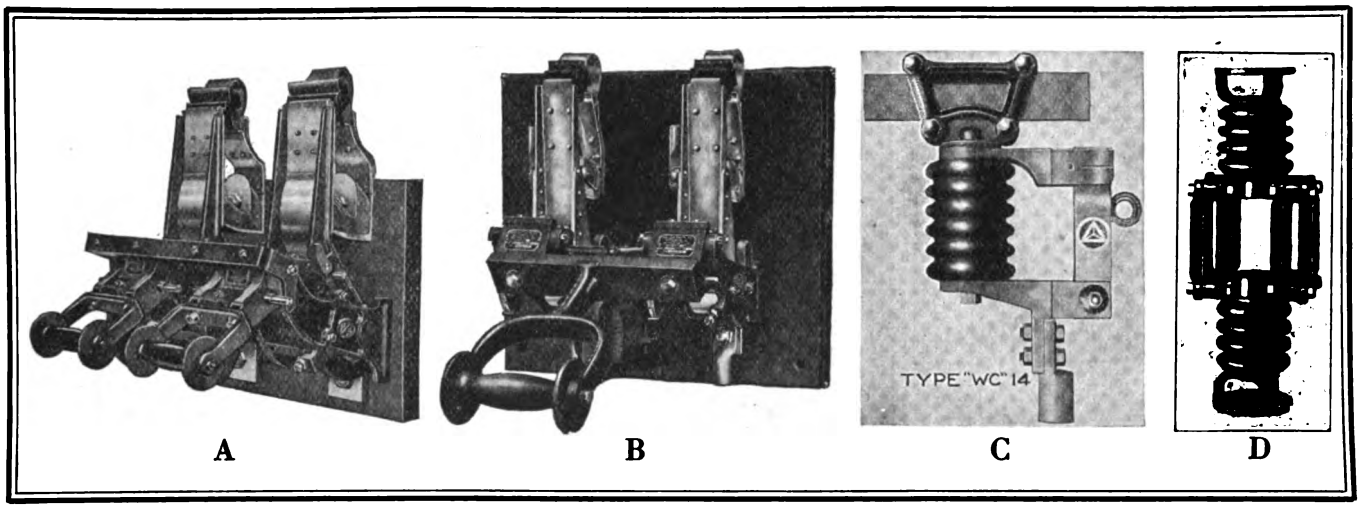
The enclosed line of circuit breakers made by the Cutter Company, Philadelphia, and sold under the trade name of "U-Re-Lite" has been expanded by the development of three new and larger "U-Re-Lites" which will handle currents up to 400 amp. at 250 volts, 200 amp. at 440-550

The savings that automatic substations can make are being increasingly appreciated by industrial plants.

At *A* is shown the automatic switching equipment controlling a synchronous motor-generator set. This equipment was made by the General Electric Company and is installed at the mines of the Heisley Coal Company, Nanty-Glo, Pa. *B* is the "Safe-for-All" circuit breaker made by the Automatic Reclosing Circuit Breaker Company, Columbus, Ohio. The wiring is connected to the terminal board at the left; the circuit breaker mechanism and cover can then be quickly removed and replaced with a spare should the occasion arise. At *C* is shown the latest type of flow indicator made by the Westinghouse Electric & Manufacturing Company for use with water-cooled transformers. *D* is an improved type of dehydrating breather made by the same company for use on transformers. It has an indicator that tells when the calcium-chloride charge has become saturated and requires renewal.



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Improvements in substation equipment designed to give more convenient and reliable operation.

At *A* is shown a new interlocked trip, circuit breaker made by the Roller-Smith Company, New York, N. Y., which is designed so that with one pole of the breaker closed, this pole will open immediately if the other is closed on an overload. *B* is a shock-proof circuit breaker developed by the same company for use in locations subjected to excessive vibration. *C* is a bus-type disconnecting switch brought out by the Delta-Star Electric Company of Chicago, Ill., for use in installations that are congested. *D* is a new bus support developed by the same company for supporting bars of high ampere-capacity.

volts, alternating current and 1,250 amp. at 250 volts, direct current. These new "U-Re-Lites" are larger in size and heavier in construction than the smaller types and are built with heavier parts and more liberal spacing to withstand the severe duty for which they are intended. Like the smaller types, they are said to be constructed in a manner such as to make it impossible to close them effectively against an abnormal circuit condition, and at the same time to furnish complete protection to the operator.

An enclosed-type circuit breaker known as "Safe-for-All" has been developed in sizes up to 200 amp. by The Automatic Reclosing Circuit Breaker Company of Columbus, Ohio. The purpose of this breaker is to provide individual motor protection in steel mills and industrial plants generally, in a form that is safe not only for the operator but also for the maintenance or repair man.

The manufacturer states that the outstanding feature of this circuit breaker is that the operating mechanism together with contacts, relays and so forth may be removed and replaced with a new unit in ten seconds.

As can be seen in one of the accompanying illustrations the device consists of three parts: a terminal board to which the wiring is connected, a circuit breaker panel, and an enclosing cover. The circuit breaker panel is hung over the terminal board from two lugs on the back. The circuit breaker cannot be closed until the enclosing cover is hung over it and latched in place by a lever located at the bottom of the cover.

This connects the circuit breaker panel to the terminal board and releases the operating handle so that the circuit breaker may be closed. The ease with which the circuit breaker panel may be removed and replaced with a spare can be readily imagined.

Several new features in breaker design have been incorporated in its type CL circuit breaker by the Westinghouse Electric & Manufacturing Company. Among them are: adjustment of brush pressure, one-piece frame construction which makes installation easy, and unit construction, permitting the addition of various attachments without difficulty.

Oil Circuit Breakers.—The problem of increasing the interrupting capacity of oil circuit breakers already installed without making radical changes in the station layout plans has been met by the General Electric Company by the production of an oil circuit breaker unit which is said to give an increase in interrupting capacity of approximately 40 per cent. Overall dimensions of this unit are identical with those of the lower-rupturing capacity unit which it replaces, except that the tank is somewhat higher. This, of course, makes it necessary to raise the cell tops, lengthen the tie rods of the old cell structures and build up the cell walls to the required height.

Factory built and completely assembled switching equipment has been developed on an extensive scale. These are commonly known as truck type switches. More than 500 of these have been placed in operation in the past year, is the report received from the Westinghouse Electric & Manufacturing Company. Each unit consists of a steel housing with a removable truck carrying all the apparatus upon which continuity of service depends.

During the year a new line of safety, enclosed switchboards with removable truck-type panels has been put on the market by the Condit Electrical Manufacturing Company of South Boston, Mass. Housing and truck are of heavy, reinforced steel-angle construction. The truck is provided with removing and replacing bar and adequate mechanical interlocks. A steel panel carries the face plate for manually- or electrically-operated circuit breakers, meters, indicating lamps, etc. Automatic safety devices prevent accidental contact with current-carrying parts when the truck is removed for repair or overhauling.

Oil Cleaners.—A device for making dirty switch oil as good as new is reported by the Sharples Specialty Company of Philadelphia, Pa. This device is known as the Sharples Super Centrifuge and the company informs us that it accomplishes the following: Carbon and moisture are removed. Resistance to emulsification is restored. The reconditioned oil is light-colored, clean and will meet dielectric strength specifications. It will give the same length of service as new oil.

A new and improved type of blotter-type, oil filtering outfit has been developed by the Westinghouse Electric & Manufacturing Company. This replaces the 10-gal. outfit formerly

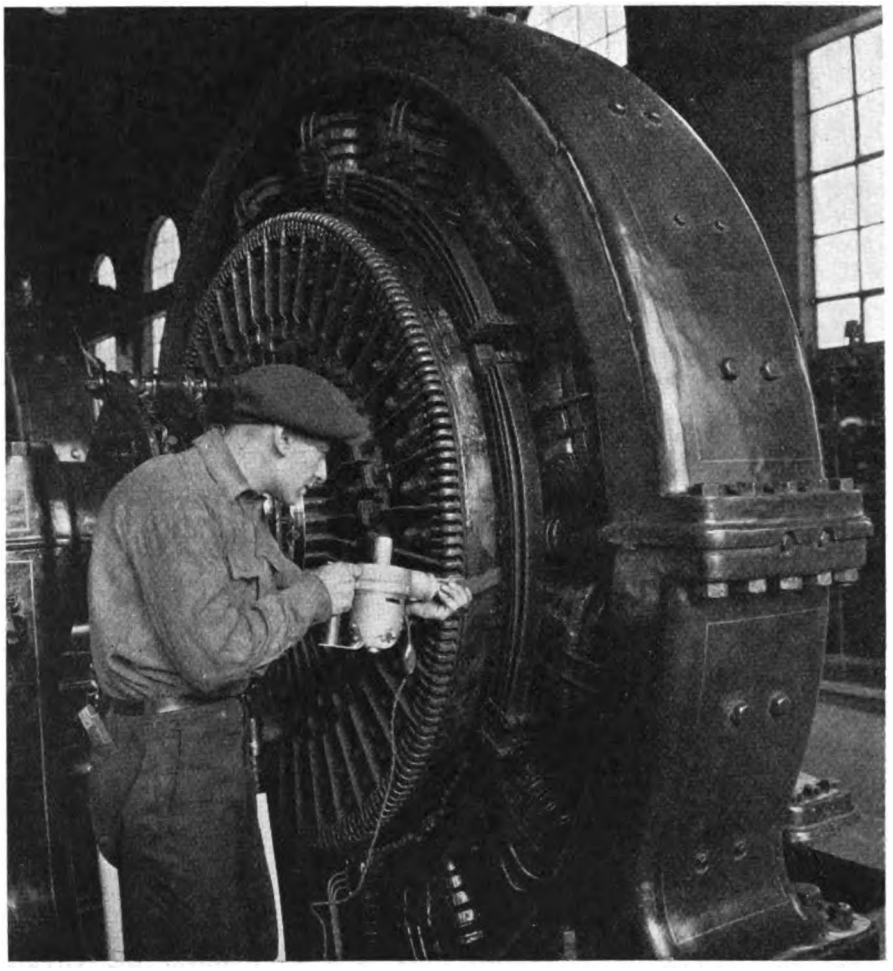
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Some Recent Developments in

Maintenance Tools and Repair Shop Equipment

That Have a Wide Range of Usefulness; Do Better Work Than Homemade Makeshifts, and Are No More Expensive in the Long Run



A thorough cleaning of machines is possible by the use of a portable blower. This blower, made by The Martindale Electric Company of Cleveland, Ohio, not only forces a blast of clean, dry air over the surface to be cleaned, but also con be used as a suction cleaner.

MAINTENANCE of plant equipment is always with us and cannot be neglected for long without disastrous results to quality or quantity of production.

Maintenance is often looked upon as a necessary evil because of the number of men seemingly unproductively engaged in the upkeep of the plant equipment. Plant maintenance involves an infinite variety of repair jobs requiring various kinds of tools.

With ordinary kit tools a man engaged in maintenance work can spend considerable time on a simple job or else bring it to the repair shop to take advantage of better tools, but this method consumes time not only for dismantling the broken machine but also for taking it to and from the repair shop.

The solution of the problem of reducing maintenance expense lies in substituting for kit tools, portable power-driven tools, that enable the repairman to do his work in shorter time, with less dismantling of equipment, and the saving of time spent in going to and from the repair shop.

Likewise, repair shop costs can be reduced through the use of improved shop tools that can do better jobs and more of them, in less time than was formerly considered necessary. In addition to the items mentioned, there is also an increase in the life of the repaired equipment obtained through the use of better repair materials.

Manufacturers are endeavoring to meet this need for cheaper maintenance by producing improved tools for maintenance and shop use, by supplying improved repair materials, and by increasing their facilities for supplying repair parts in less time than was formerly required.

HOW CAN I reduce my maintenance and repair cost, is the problem that is constantly before every maintenance executive, be he maintenance engineer, superintendent, foreman, or straw boss. During the past year many manufacturers have devoted much effort towards arriving at the solution to this problem. In this article are described some of the recent developments in repair shop and maintenance tools and supplies that will help you reduce your maintenance expense.

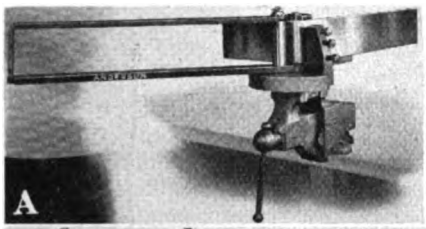
Great strides have been made in the use of arc welding for plant maintenance; likewise there have been developments in coil winding machines, armature repair equipment, portable power-driven tools, and repair supplies.

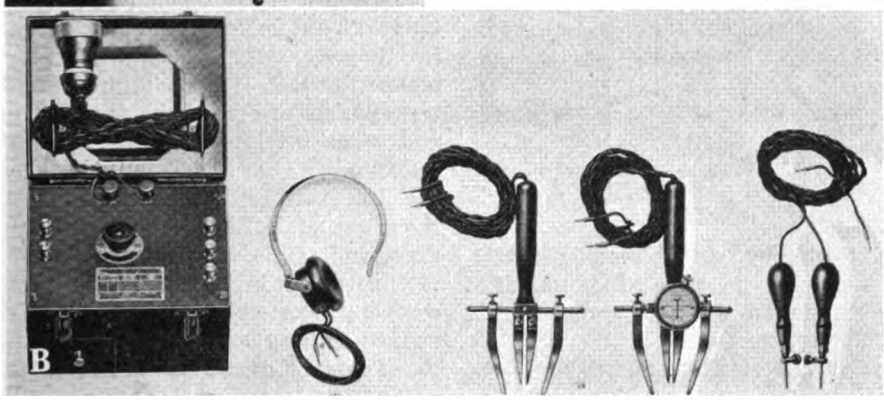
We will consider each of these developments in turn.

Armature Coil Winding Machines.—During the past year the Armature Coil Equipment Company of Cleveland, Ohio has placed three new coil winding and forming machines on the market.

The first of these, known as the Master Coil Making Machine not only winds the coils but forms them in the same machine. Coils are wound in a loop shape over winding jaws as shown in one of the accompanying illustrations. One of the features reported for this part of the operation is that the loop is started and finished in the same position, thereby eliminating the

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Good repair work is a natural result from the use of good tools.

At *A* is shown a bus bar or sheet metal bender made by the Albert & J. M. Anderson Manufacturing Company of Boston, Mass. *B* is a new model armature tester made by The Century Electrical Company of Syracuse, N. Y. The maker reports that this model is designed for use on all commercial alternating-current voltages.

necessity of making an extra half-turn of the machine before starting each loop.

The next operation is to release the coil from the winding jaws by a single universal lever movement that permits a simple, quick-action chuck to receive the coil end. The coil is then clamped in two sets of jaws and formed by pushing down on the foot lever of the machine. Coils that require complete taping are wound, formed, bound and then removed from the machine for taping. Coils that have only the ends taped are taped in the machine after forming.

This company has also made several very useful improvements to its loop winding and coil forming machines. One of the points featured by the maker is that scales have been added to both machines so that they can be set for certain definite measurements taken from the coil, thus doing away with the cut-and-try method of setting a machine to make a certain coil. The manufacturer reports that measurements for a given coil can be recorded in a card record system and a coil reproduced by setting the machine according to the values recorded on the card.

The data recorded on an armature winding card would ordinarily be the size, type, make and nameplate rating of the motor; number of coils; the size of wire used in the coils; the number of wires in multiple; the length of the leads; and how the coils are taped. In addition to this the following information would be recorded for use with these machines: length of loop, length across the core, slot pitch and coil span.

In one of the accompanying pictures is shown the improved loop winder which is known as the New Super-Speed Loop Winder. On the bar holding the winding jaws will be noted a scale marked in inches. By means of this scale the length of the loop is set. The maker states that an additional feature of this winder is the quick time in which a loop may be removed and the machine reset for the next loop—a single quick-action lever accomplishing the operation.

The coil is then placed in the New Improved Armature and Stator Coil Former which is also shown in an accompanying illustration. The forming jaws are set on a scale marked in inches for the length of the coil measured across the armature core. These forming jaws rock on a shaft which has a dial calibrated in degrees. The slot pitch in degrees is set on this dial. The coil span measured in degrees is set on still another dial.

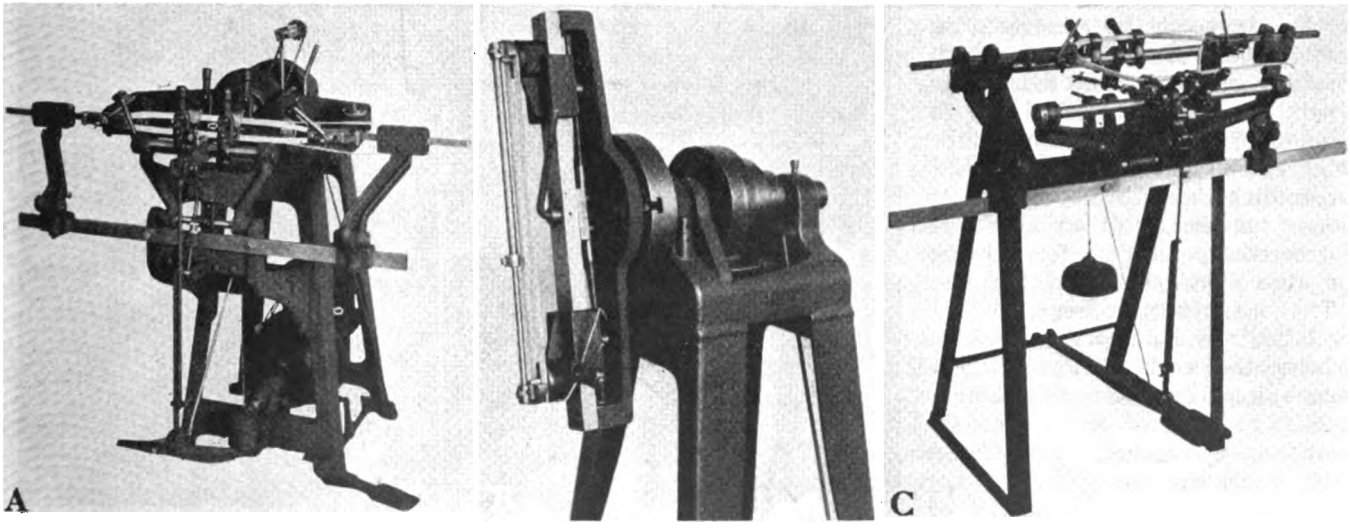
The manufacturer states that in this manner all the dimensions of the coil are thus set on the machine and consequently the coils may be reproduced at any time from recorded data without the use of cut-and-try methods.

Improvements have been made to the reel rack and tension device made by the Mutual Foundry & Machine Company of Atlanta, Ga. The maker reports that unusual results have been secured when using this device on cotton covered magnet wire.

W. Edlich of Delawanna, N. J., reports that he is handling the R. Ritter armature winding machine, which is manufactured abroad. These machines are made in two sizes which will wind coils directly

Three new coil-winding machines developed by the Armature Coil Equipment Company, Cleveland, Ohio.

At *A* is shown a combination coil winder and former. *B* is a coil winder and *C* the former that goes with it. A feature of these two machines is that all of the essential measurements of the coil may be set on graduated dials or scales and thus the coil is made to measure.



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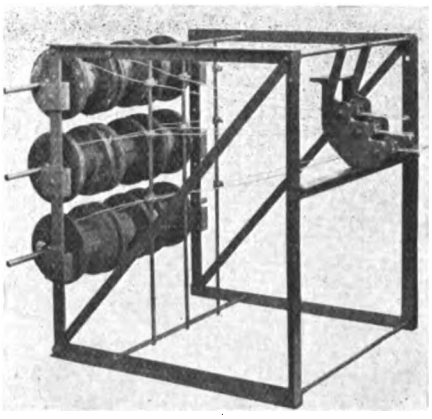
into the armature slots on armatures from 1½ in. to 7 in. in diameter. Mr. Edlich states that a remarkable saving in time can be obtained by the use of this machine as compared to hand-winding methods.

Armature Testers.—A new model armature tester has been placed on the market by The Century Electrical Company of Syracuse, N. Y. The maker reports that this tester instantly detects and exactly locates shorts, opens, wrong connections, and grounds, in armatures, without the necessity of unsoldering any lead wires from the commutator or disturbing the hoods. It may be operated from either alternating- or direct-current circuits, or from a battery when power circuits are not available. The tester is provided with both receiver and meter types of testing forks, and a ground detector. A trouble, or search lamp, is supplied which the maker states is a very useful article and saves much time because it can be inserted behind commutators or into small spaces between windings where a large lamp would be of little use. The tester is shown in an accompanying illustration.

Commutator Slotters.—Several new commutator slotters or mica undercutters have been placed on the market during the past year. The Hullhorst Micro Tool Company of Toledo, Ohio, has designed a portable- and a lathe-type mica undercutter (both of which are shown in accompanying illustrations) as well as an undercutting machine for small armatures. A feature of these three undercutters is the very small cutting tool that is used—a cutter ¼ in. in diameter being used for a 1/32-in. cut and a 9/32-in. diam. cutter for a 3/64-in. cut.

The manufacturer states that the portable type consists of a motor, a flexible shaft protected by a metal sheath, a spindle within a quill, an arbor removably attached to a spindle, a bearing to support the outer end of the spindle, a handle for guiding the cutter, and a fan or blower together with an air-nozzle and necessary air duct for blowing the mica shavings out of the slot.

The manufacturer reports that the lathe-type undercutting machine reduces the cost of undercutting commutators to a very low figure, both as to tool cost and labor. By means of a swinging arm and a depth guide bar the machine is adjusted for direction and depth of cut; thereby, as the maker states, making it possible for unskilled operators to do fast and accurate undercutting.



A handy combination reel rack and tension device.
The Mutual Foundry and Machine Company reports that it has incorporated several improvements in the new design of this device.

For undercutting the mica in the commutators of small armatures, the Ransom & Randolph Co., Toledo, Ohio, has recently placed on the market an undercutting machine that is quickly adjustable to accommodate any type of small armature up to 22 in. in length and 11⅞ in. in diameter. This company also makes the R & R Mica Milling Cutters which are used in the above and other machines.

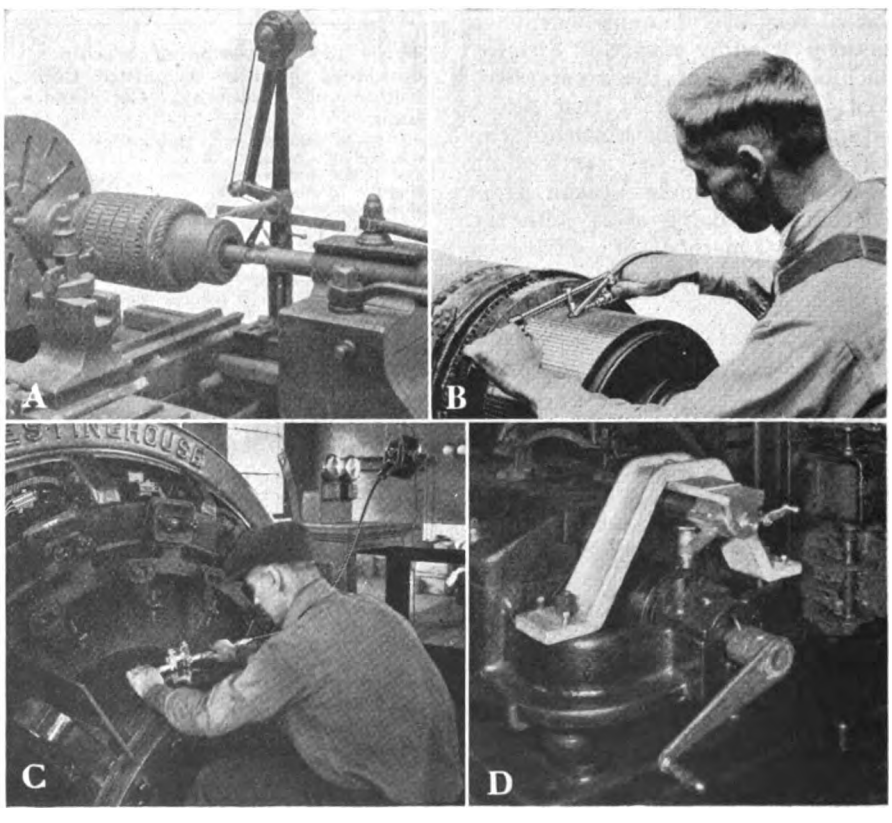
A flexible shaft has been added to the Imperial Undercutter made by the Martindale Electric Company of Cleveland, Ohio. This undercutter is illustrated in this article. This company has also developed a V-shaped milling cutter for use with the Aurand Commutator Slotter.

Commutator Turning Tools.—A tool for truing the commutators of motors or generators without removing the armature from its bearings has been put on the market by the Green Equipment Corporation of Chicago, Ill.

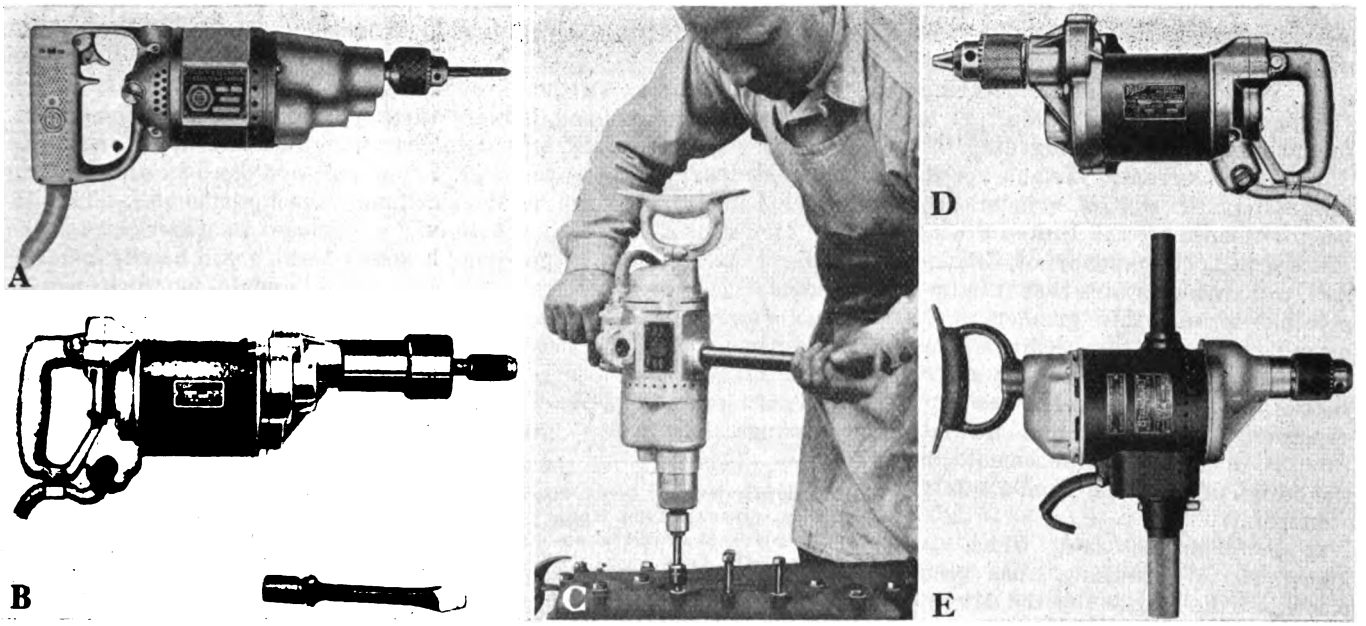
The maker reports that with this tool a perfectly true, smooth surface can be made in the same manner as in a lathe, the commutator being turned either by its own power, a crank or a separate motor for that purpose. This device is shown in one of the accompanying illustrations.

Portable Power-Driven Tools.—During the past year a large number of portable, power-driven tools

Four commutator tools designed for fast, high-grade work.
At *A* is shown the lathe-type, mica undercutting machine made by The Hullhorst Micro Tool Company of Toledo, Ohio. This device can be quickly attached to any lathe and is so arranged that it can be swung out of the way when not in service. At *B* is shown the portable, mica undercutting machine made by the same company. It is driven through a flexible shaft by a small motor which has a fan that blows through the air duct shown. *C* is an improved mica undercutter that is driven by a motor through a flexible shaft and is made by The Martindale Electric Company, Cleveland, Ohio. At *D* is shown the Leonard-Morrow commutator turning tool distributed by the Green Equipment Corp., Chicago, Ill.



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Here are five portable tools that can save money on any repair job. At *A* is shown a motor-driven tapper made by The Black & Decker Manufacturing Company of Towson, Md. *B* is a motor-driven, friction-head, screw-driver, made by The Hisey-Wolf Machine Company of Cincinnati, Ohio. At *C* is shown a motor-driven, reversible socket wrench manufactured by The Black & Decker Manufacturing Company. *D* is a portable, slow-speed drill for drilling slate and marble. It is made by The Hisey-Wolf Machine Company. At *E* is shown an improved model, portable drill manufactured by The Standard Electric Tool Company, Cincinnati, Ohio.

have been placed on the market. These are of particular interest to the maintenance man for they enable him to bring the facilities of the repair shop to the job in hand.

Several new portable drills have appeared on the market during the past year. A slate and marble drill has been developed by the Hisey-Wolf Machine Company of Cincinnati, Ohio. Since the drilling of such material can be accomplished only at slow speed, this drill has been designed for a no-load speed of 110 r.p.m.

An improved ½-in. drill weighing 17 lb. and equipped with ball bearings has been placed upon the market by the Standard Electric Tool Company of Cincinnati, Ohio. The two drills which have just been mentioned are shown in the illustrations accompanying this article.

The Temco Electric Motor Company of Leipsic, Ohio, has developed two new portable, motor-driven drills, one in the ¼-in. size and the other for 5/16-in. drills. This company has also put on the market a drilling stand to hold its portable drill so that the combination may be used as a drill press when desired. By the use of a bench clamp and by fitting the chuck with a Temco arbor and grinding wheel, the ¼-in. drill may be used as a bench grinder. The maker states that this constitutes a very flexible and economical arrangement of portable tools for the small shop.

A friction-head, motor-driven screw driver, that is said to have sufficient capacity to drive No. 14 screws, 2½ in. long into solid soft wood, has been placed on the market by The Hisey-Wolf Machine Company of Cincinnati, Ohio. The maker states that by the use of the proper sockets, this machine can be used for setting nuts up to and including ⅜ in. in size. The driving head is equipped with a disk friction clutch that is automatically regulated by the pressure applied. The clutch casing is of convenient size and can be used as an end grip when the work requires it.

A motor-driven, reversible, socket wrench has been developed by The Black & Decker Manufacturing Company of Towson, Md. This machine is essentially the same in construction and design as the Black & Decker Portable Electric Drill except that the spindle is provided with a clutch that automatically releases when the forward pressure on the tool is relieved. The maker states that due to the design of this clutch, a nut, bolt or stud can be driven to any desired tightness. A reversing switch is provided for use in disassembling motors and machinery and the wrench has ample power to kick nuts or bolts loose, regardless of how tight they are drawn up.

This company has also developed a motor-driven tapper. The maker reports that this device is so designed that the tap is driven in at a speed of 350 r.p.m and, by a slight backward pull on the machine, the tap chuck is automatically reversed and the tap backed out of the threaded hole at double the speed it is driven in. No reversing switch is needed.

A bench grinder for quickly and accurately grinding twist drills up to ⅝ in. in diameter has been placed on the market by The Black & Decker Manufacturing Company of Towson, Md., according to reports received from them. The maker states that the twist drill is fed to the grinding wheel by means of a micrometer screw feed, and that no adjustments are necessary for grinding different size twist drills, this being compensated for in the design.

Heretofore, small repair shops have had to depend upon "free-hand" methods of grinding twist drills because they could not obtain a machine to do the job quickly and accurately at a price which could be afforded. The maker feels that this grinder fills a long-felt need and its use will insure twist drills being ground at the right angle, with proper clearance and with both cutting tips exactly the same length.

A 6-in. bench grinder has also been placed on the market by The Hisey-Wolf Machine Company of Cincinnati, Ohio. This company has also developed a wide-swing, floor-stand grinder, which is especially adapted to grinding large bulky castings and irregular-shaped pieces.

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A bench grinder that has spindle bearings which the maker states are dustproof has been developed by The Azor Motor Manufacturing Company of Cleveland, Ohio. It is adapted for light grinding duty.

A direct-current, variable-speed, semi-automatic control grinder has been developed by the United States Electrical Tool Company of Cincinnati, Ohio, which states that it is impossible to use this grinder at a peripheral speed exceeding the maximum safety point or at a speed that is less than considered best for grinding. The maker points out that this is a great advancement in the design of grinders, from a safety standpoint.

A motor-driven saw, which is known as the "Skilsaw," has been placed on the market by the Michel Electric Hand Saw Company of Chicago, Ill. How conveniently this saw can be used to cut out sections of an old floor is shown in an accompanying illustration. The maker reports that the saw is extensively used for cutting open boxes without endangering their contents. He also states that it can save money wherever there is sawing to be done for maintenance or repair work about the plant. Special cutters are provided for use when sawing various building compositions and insulating materials and the device can also be fitted with abrasive discs for work in light sheet metal, bars or tubing.

The maker states that the essential features in connection with the construction of this tool are an 8-in. circular saw or cutter which is readily detachable and is driven by means of a worm connected to the armature shaft of a universal motor. The entire body is made of aluminum. The long guide encircling the saw supports the tool when in operation and is vertically adjustable to limit the depth of the cut. A spring steel guide at the rear of the saw is made of the same gage as the saw itself and follows in the kerf, thus preventing twisting of the saw blade while in use.

The Imperial "Blow-er Clean," a motor-driven blower, has been put on the market by the Martindale Electric Company of Cleveland, Ohio. The maker states that this device, which is shown in one of the accompanying illustrations, operates perfectly as a suction machine or as a blowing device in removing coal dust, dirt and accumulations from machinery, particularly electrical installations, where these accumulations have a tendency to set up short-circuits.

The manufacturer further reports that when operated as a blower the air leaves the nozzle at a velocity of 200 feet per second—over 140 miles per hour. The large volume of dry air insures more thorough and safer cleaning than is possible with compressed air.

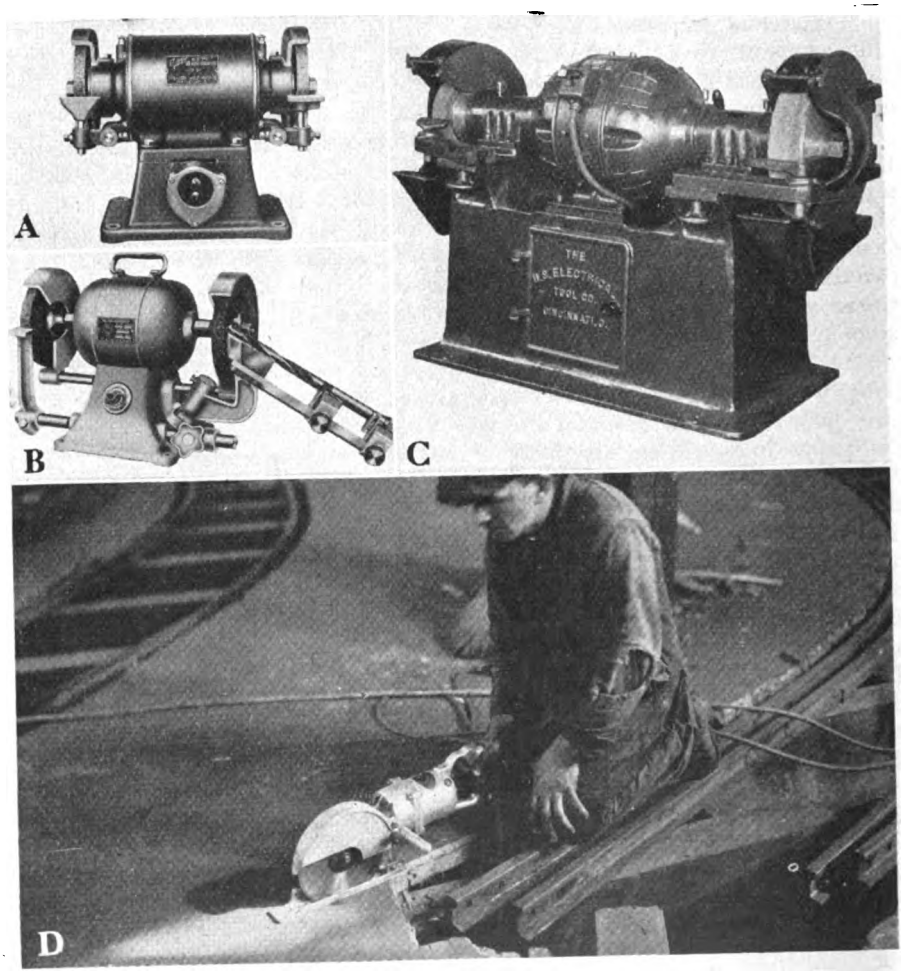
A motor-driven blower has also been developed by the Temco Electric Motor Company of Leipsic, Ohio. This blower is equipped with ball bearings, has a fan speed of 12,000 r.p.m., and weighs 5 lb. net.

A busbar or flat-metal bender has been placed on the market by the Albert & J. M. Anderson Manufacturing Company of Boston, Mass. The makers state that this machine is portable and can be clamped in an ordinary machinist's vise. The device is made in three sizes, the largest of which will handle material 10 in. wide and ⅜ in. thick.

Welding Machines and Supplies.—A new type of electric, arc welding generator has been placed on the market by the Allan Manufacturing & Welding Company of Buffalo, N. Y. These generators may be driven by belt, by direct-connected motor, as shown in the accompanying illustration, or by gasoline engine. The manufacturer reports that the chief troubles of direct-current generators are in the commutator and the difficulty in replacing burned-out armature coils; these two troubles are entirely eliminated in his welding generators for two slip rings replace the commutator, and either eight or ten armature coils, depending upon the speed of the machine, replace the many coils of direct-current, welding generator armatures. In addition to the two above-

Conveniently located bench tools or portable power-driven tools will soon pay for themselves on maintenance work.

A is a small bench grinder made by The Hisey-Wolf Machine Company of Cincinnati, Ohio. *B* is a drill grinder and bench grinder made by The Black & Decker Manufacturing Company of Towson, Md. At *C* is shown a variable-speed, semi-automatic control grinder manufactured by The United States Electrical Tool Company of Cincinnati, Ohio. The maker states that it is impossible to overspeed this machine or to run it at a speed lower than is considered best for grinding. *D* is a portable, power-driven saw, known as Skilsaw, which is shown cutting flooring. It is made by the Michel Electric Hand-Saw Company of Chicago, Ill. The maker states that this machine will also cut building compositions and insulating materials as well as light sheet metal and bars or tubing.



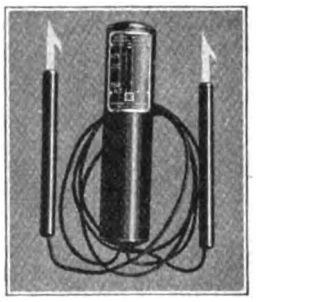
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mentioned advantages, there are no complicated windings or connections of field coils. The maker also states that this welding generator has embodied in it the semi-arc feature for use in connection with the welding of light, cast-iron sections, particularly defective automotive cylinder blocks.

A new single-operator arc welding machine rated at 200 amp. has been placed on the market by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The manufacturer reports that this machine will operate over a much wider range of current than previous machines, has better welding characteristics and has been very much improved and simplified in general construction. The outstanding feature of this machine is said to be its ideal current characteristics which make it easy to strike and maintain the arc, thereby giving good fusion and homogeneous welds. This machine is shown in an accompanying illustration.

A welding machine that will operate from any industrial power supply has been developed by the Electric Arc Cutting & Welding Company of Newark, N. J. The maker points out that by means of multiple, series-multiple and series combinations of the coils of the primary winding, together with taps and adaptor windings, the welder can be made to operate on 110, 220 or 440 volts, alternating current, of 25, 40 or 60 cycles. It is also claimed that by the use of a resistor-reactor combination inserted in the secondary winding, the welder can also be operated from a 110- or 220-volt, direct-current power supply. This company also informs us that a final decision of the patent litigation involving its welding machines has been rendered in its favor by the Circuit Court of Appeals of the District of Columbia.

A new type of direct-current arc welding generator in which the adjustment of the welding current is obtained by shifting the generator brushes has been developed by the General Electric Company. This machine is rated at 250 amp., 1 hr., 50-deg. rise, and 200 amp. continuous, and is also capable of handling a maximum welding current of 300 amp. This manufacturer reports that the use of automatic arc welders showed a consistent gain during the past year, and new types of machines were produced for use in manufacturing them.



A voltage tester is a convenient tool for the repair man.

This tester is made by the Square D Company of Detroit, Mich. In the top illustration is shown the new brick and cement drill made by the Van Expansion Bolt Manufacturing Company of Chicago, Ill.

H. Kleinhans Company of Pittsburgh, Pa., reports that it has developed a gasoline-engine-driven welder and a motor-driven welder which have unusual operating economy, inasmuch as the welding generator generates only sufficient voltage to supply the arc and lead voltage drop, thereby doing away with the losses due to an external resistance or control apparatus.

The Lincoln Electric Company of Cleveland, Ohio, reports that it has improved its arc welder by building the frames of the generator and motor of rolled steel instead of castings. This has brought about a decrease in weight for a given size of welder and at the same time gives a more rugged machine than formerly built. This machine is shown in one of the accompanying illustrations.

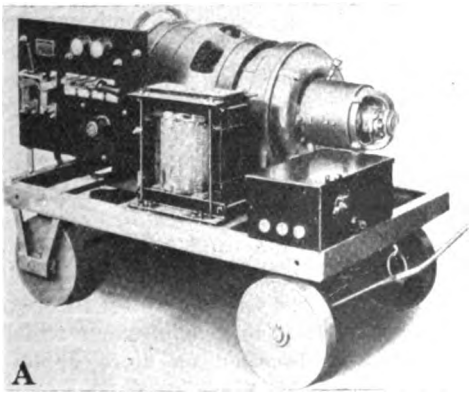
A new welding electrode which the maker informs us differs radically from other electrodes in its makeup and characteristics, has been developed by the General Electric Company. This electrode consists of a central metallic core surrounded by a layer of flux, which is protected by a metallic sheath. The maker points out that this special construction, together with the use of a special flux, results in unusual arc stability, ease of manipulation and rapid deposition. The electrode can be used on either alternating- or direct-current systems and is particularly recommended by the maker for welding cast iron and galvanized iron.

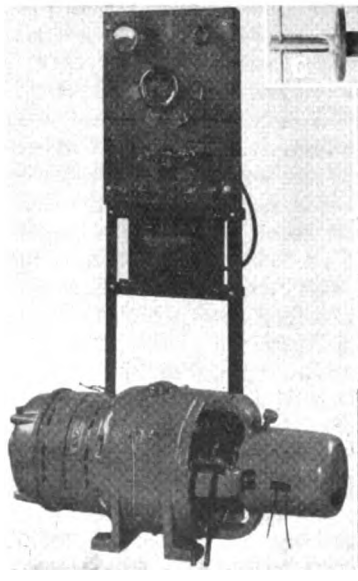
A new type of welding electrode holder marketed by the General

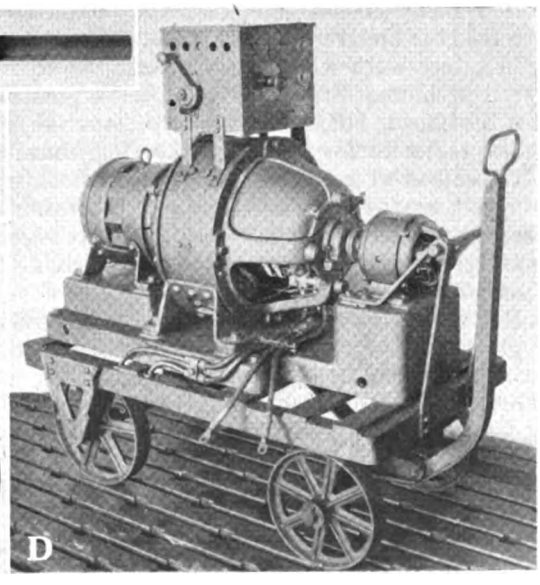
(Please turn to page 110.)

Arc welders have definitely shown their money saving possibilities in industrial plants.

Here are three new or improved arc welders that have been put on the market during the past year. The one shown at *A* is made by the Lincoln Electric Co. of Cleveland, Ohio; *B* is made by the Allan Manufacturing and Welding Company of Buffalo, N. Y.; and *D* is made by the Westinghouse Electric & Manufacturing Co. The machine at *A* is an improved model in which rolled steel has been substituted for cast steel in the motor and generafor cast steel in the motor and generaweight. *B* is an entirely new machine. The outstanding feature of the welder shown at *D*, as stated by the maker, is its ideal current characteristic. *C* is a new electrode holder developed by the General Electric Company.







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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT F. E. GOODING A. J. WHITCOMB

Chicago, February, 1925

Industrial Accidents Cost a Billion Dollars a Year

IN A recent report the Metropolitan Life Insurance Company has pointed out that industrial accidents cost this country every year not far from $1,000,000,000. This startling figure is due to about two and a half million to three million accidents a year that result in a loss of more than one day's working time. The principal types of permanent partial injuries are: fingers and thumbs, 57.7 per cent; eyes, 7.6 per cent; legs, feet and toes, 5.9 per cent; arms and hands, 3.8 per cent. Although the percentage of eye disabilities is relatively low, it is most serious, for the loss of an eye cannot be corrected by artificial methods in the way that these corrections can be applied to legs, arms, and hands.

The distribution of fatal accidents places manufacture second to transportation with these two groups of work sharing about equally 48.3 per cent of all fatalities; agriculture and mining account for about 15 per cent each, construction about 9 per cent and all other work about 12 per cent.

With manufacture charged with nearly one-quarter of the fatal accidents to 4,200 to 5,700 persons each year, coupled with two and a half million to three million disablements annually, the importance of safeguards is apparent to any thinking persons. Education in safety work will go a long way toward reducing this toll of human life and its reduced efficiency in earning a livelihood, but it can never replace the need in mills and factories for safety engineering aimed at removing the causes of accidents and making machines and operations as foolproof as possible. Certainly, if a dollar spent will save a dollar loss in accidents, the extent of safety engineering in this country should be on a scale of not less than one billion dollars expended every year. But such a result can not be hoped for until safety engineering is more universally established and American industry can well afford to spend now a greater sum, even up to four or five times the cost of industrial accidents, to stem the tide of accident losses in life and loss of production time, and wait for its return during the next decade. Such a contribution to humanity will prove a wise investment that should be neglected no longer. There are many good reasons for making it.

A good way to start is to join the National Safety Council and plaster your plant with its effective safety bulletins. Then organize a safety engineering department and eliminate the death- and accident-traps throughout your works.

New Industrial Contruction During 1925

THE building program for 1925 as forecast by the *Architectural Forum* will call for an expenditure of around five billion dollars in new buildings. Seven of the 19 groups of construction work that are reported and call for an expenditure of more than 300 million dollars each, account for 66 per cent of the total of five billions of dollars. Industrial buildings are listed as fifth in the group of seven at a cost of $392,367,000, with hotels and churches each calling for about the same amount. Schools head the list with a cost of $726,858,000 which, with the exception of apartment construction, represents nearly twice the cost of any one of the seven largest items.

In percentage the industrial building program calls for more than seven per cent of the total expenditure and about the same as in 1924. This is healthy growth and seems to be pretty evenly divided for all sections of the United States, with the largest percentages assigned to the Middle West and Northeastern states.

This amount of new industrial construction is going to call for much new electrical and mechanical work and many changes and rearrangements in the complete works where this new construction will extend or add to existing plant facilities. Careful planning of plant layout is called for in this new work and we hope with the co-operation of our readers to present in these columns during the coming year the results of the best thinking it will represent.

Saving Half On a Belting Installation

READERS are familiar with the more or less common practice of using recording instruments on the power line to a machine to see whether it is under- or over-motored and as a check on whether wear in bearings, gears or moving parts has become so great as to cause excessive loading.

Recently another unusual use has been made of these power recording instruments. A large automobile factory was planning a new layout and rearrangement of many of its machines. Before the change was made tests were run on individual machine tools which were operated in large groups or batteries, such as gear cutters, screw machines and others. Tests on one type of machine indicated, for example, that a 2-in. belt was large enough for operation on the special, light work which this machine was doing, instead of the 5-in. belt which the machine manufacturer had provided for when making allowance for a drive which would take care of the maximum capacity of the machine.

A similar study of motoring and belting of machines to see what savings can be made will pay handsome profits in almost any plant that has been in operation a few years without changes in equipment which was originally bought and installed on more or less

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guesswork as to the best kind of drive to use. Of course, if a machine is operating on general work it may not be advisable to go much below the manufacturer's recommendation for the power drive. However, many machines are on straight production with light loading which never changes and here is one instance where the machine and its drive should be suited to the job being done and not to the possible range of work on which it can be used.

Making Research Data Usable to Practical Men

READERS of INDUSTRIAL ENGINEER have noticed, perhaps, that its pages have been almost entirely free from papers describing elaborate researches or highly technical discussions on theoretical subjects. There has been a reason for this.

Research and theoretical discussions have a very important place and value and should not be depreciated. This place is, however, where the design of equipment originates. The practical operating man with his multitude of duties seldom has the time nor opportunity to thoroughly digest these papers and determine how the useful findings may be applied to his work.

Recently a prominent practical engineer, well known to the readers of this paper, mentioned the value of "translating" and "practicalizing" some of these reports so that the findings can be more readily appreciated and applied by plant men. In speaking of a recent report on belt drives, which are closely associated with his work, he remarked: "There is mighty good stuff in that report but it would take me at least a full day to make it usable. I am glad to learn that the laws controlling this work have been determined but I cannot give this report to an assistant and let him apply it. This report is meant for engineers who devote their whole time to this subject, which, to me, is only one item of my work. Couldn't the Editors of INDUSTRIAL ENGINEER or some other practical men put this information into charts, curves, tables or diagrams which would give us the results in five minutes with only simple calculations?"

Perhaps other readers have had similar ideas. INDUSTRIAL ENGINEER is making an investigation of the report in question and the readers will benefit from it shortly. The Editors are always anxious to hear of an opportunity to be of service to their readers in this way.

Watch Your Scrap Pile

ON a recent trip through a large industrial works, we were impressed by the clever use of a great deal of material that otherwise would have been scrapped as having outlived its usefulness.

A steam-engine-driven ventilating fan was to be removed to a new location where space was at a premium and where no steam supply was available. Instead of incurring the additional expense of a new direct-connected, motor-driven fan, it was decided to remove the steam engine from the present fan. The fan was taken off the crank shaft of the engine, a new shaft installed with a pulley on it, and the outfit connected up to a short-center, belt drive using an idler pulley. This enabled the outfit to go into the space available and resulted in a saving of not only money but also the time required to obtain the new fan.

At another place in the same plant, a flywheel and drive pulley were required for a coal crusher. Two flywheels from a discarded gasoline engine were put on the same shaft. This gave the required flywheel effect and their rims made a good pulley.

At one of the substations of this plant, three 25-cycle, 12,000-volt transformers were required to carry expected additions to the plant load. At one of the other plants of this same company, there were three 25-cycle, 20,000-volt transformers which were about to be consigned to the scrap pile on account of the substitution of 60-cycle for 25-cycle power. The transformers were opened up and rearranged for 12,000-volt operation. As the transformers were each rated at 500 kva., it meant quite a large money saving to the company.

These instances point out the fact that old equipment should not be scrapped just because the present need for it has ceased. A time may come when very good use of it can be made and will result in a considerable saving of capital investment. Oftentimes the use of this equipment will enable changes to be made that would not otherwise be considered because of the appropriation that would be required.

Teach Your Men Signs of Trouble in New Equipment

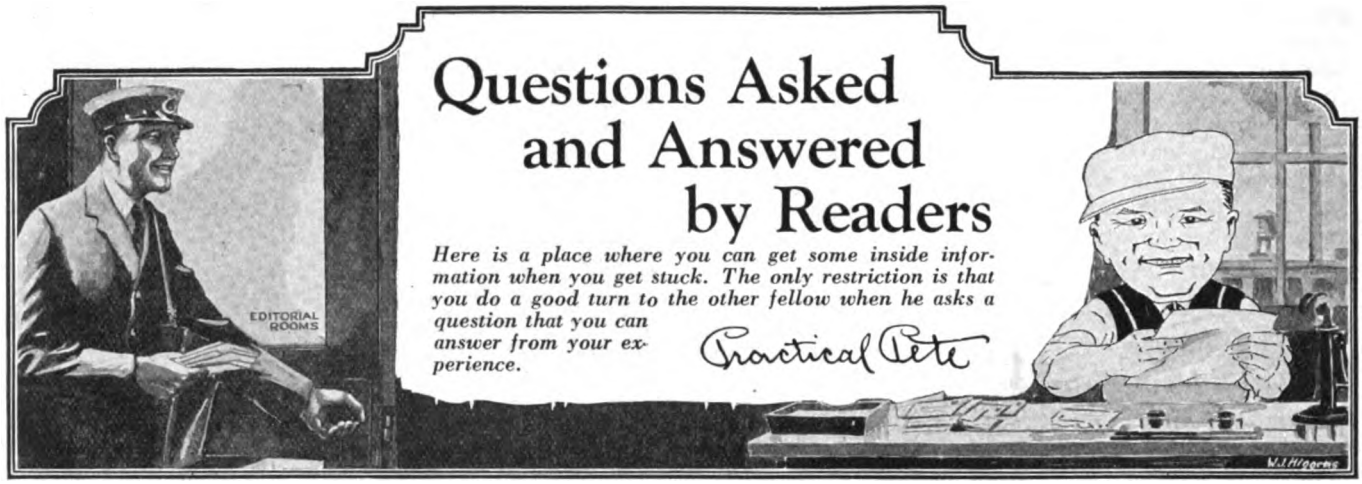
COMMENTING on the use of ball bearings in his report on changes which were made during the past year, H. D. Fisher, Plant Engineer of the New Haven Pulp and Board Company, makes the following significant statement in the article beginning on page 52 of this issue:

> We have not gone extensively into the use of ball bearings * * *. Further, until our men are more familiar with the signs which these bearings give of impending trouble we fear that we would have a disproportionate number of failures. We attribute the rather excessive trouble with those which we now have to the fact that incipient trouble is not recognized before it becomes serious.

Many plants have unusual operating conditions and there is no doubt that many pieces of equipment, particularly new types, have been unjustly blamed for failure to give service that was up to expectations because the men in charge of the equipment did not know how to take care of it and were not familiar with the early signs of trouble. Detecting trouble and remedying it before it becomes serious is the very essence of maintenance work. Repairs which are made after breakdown occurs are very likely to be much more expensive than they would be if they were made while the equipment was still in operating condition. In addition, there are the inevitable delays and loss of production, which are also expensive.

It is, however, not always possible, or advisable, to put off the installation of new equipment until the operators and inspectors are familiar with its operation and care. Consequently, when new types of equipment are to be installed it is well to secure from the manufacturer or other reliable source as much information as possible regarding the care it should be given and the manner in which signs of distress are manifested. If the inspectors and operators are then thoroughly instructed on these points, so that they will understand clearly what to look for, and where, better results will be obtained and a good deal of trouble and expense may be avoided.

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Who Can Answer These?

Supporting Lineshafting on Concrete Pillars—I have to support several long runs of lineshafting on concrete pillars and should like to know (1) if this is considered good practice. (2) Will it be necessary to use adjustable pillow blocks, or will the solid type be satisfactory? (3) Is there enough danger of the pillars settling or getting out of line to make it necessary to brace these in any way?
Brooklyn, N. Y. C. R. P.

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Number of Bars Covered by Brushes on Wave-wound D. C. Armatures—I should like to know why the brushes on a 4-circuit, wave-wound, d. c. armature cover only a little more than one segment, instead of two or more segments. I was, until recently, under the impression that the brushes had to cover as many segments as there are circuits per coil. If not, why have the four circuits?
Wichita, Kan. E. E. B.

• • • •

Lay Out of Typical Three-phase Installation—Will some reader give me (1) a diagram of a typical, three-phase power installation from the power company's wires to switchboard, including transformers? (2) What transformer connection is used most, and why?
Windsor, Ont., Can. J. A. L.

• • • •

Using A. C. Generator as Synchronous Motor—What changes, if any, are necessary in order to use a stationary-field, revolving-armature, a.c. generator as a synchronous motor? This is a Westinghouse generator, rated at 25 kva., 480 volts, 30 amp., three-phase, 60 cycles, 1,800 r.p.m., serial No. 4212835. The exciter is direct-connected to the generator shaft and is rated at ¾ kw., 125 volts, 6 amp.

I should like to use this generator as a synchronous motor to drive a centrifugal sugar drier and to correct power factor. The power supply is 480 volts and all motors are rated 440 volts. If I can use this generator as planned, what horsepower will be developed and what will be the ampere input? Will I have to have an outside supply of direct current for excitation, or can I use the exciter on the machine?
Negros Occidental, P. I. A. C. M.

• • • •

Calculating Starting Resistance for D.C. Motors—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?
Albert, W. Va. F. H.

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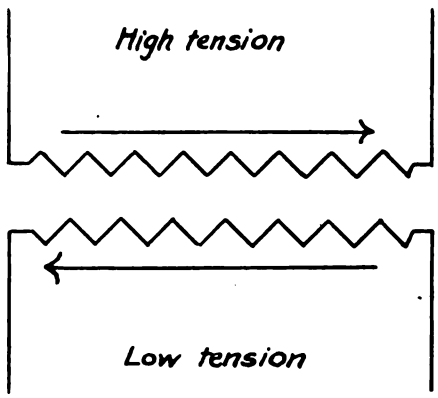
Transformer Draws Heavy No-load Current—We have a 75-kva., 25-cycle, single-phase, 2,200/220/110-volt lighting transformer which draws an excessive no-load current. The primary current with all secondary load disconnected is about 11.5 amp. at 2,200 volts. The secondary voltage is normal at 0, ¼, ½, ¾ and full load. The temperature of the oil is normal. The insulation resistance between windings and between windings and ground is over 50 megohms. What is the cause for this high no-load current?
Hamilton, Ont., Can. J. F. M.

• • • •

Reclaiming Leather Belting—I should like to know if any readers have made an investigation to determine how much belting must be in use before it will pay a plant to undertake belt reclamation work. I should also like to know the amount and kind of equipment required to do such work and about what savings we could expect to make. I shall appreciate any suggestions or information you can give me.
Cleveland, Ohio. E. E. L.

• • • •

Polarity of Transformer—After reading the article on "Checking and Testing Transformer Connections" on page 560 of the December, 1924, issue of INDUSTRIAL ENGINEER, I am somewhat confused as to the relationship between the primary and secondary voltages for transformers of different polarities. Assume a transformer having primary and secondary voltages in the winding as shown by the arrows in the diagram. Can some reader tell me whether this transformer has additive or subtractive polarity, and why?



Chicago, Ill. G. A. V.

• • • •

Reconnecting Two-Phase Motor for Three-Phase Operation—I have a 10-hp., 440-volt, two-phase, squirrel-cage motor which has 48 slots and coils, six poles, and is series-connected. Can this motor be reconnected for three-phase operation by using the "T" connection? If so, how many coils must be cut out of circuit? What will the new grouping be for three phase and what horsepower will the motor develop after reconnection, if the speed remains the same as before? What is the smallest number of coils that can be reconnected from two-phase to three phase by the "T" connection?
Iola, Kan. G. E. G.

Answers Received To Questions Asked

How to Determine When a Wave Winding Is Retrogressive or Progressive—Please indicate by formula or otherwise how to determine when a wave winding is wound progressive or retrogressive and what are the particular advantages of the progressive wave winding over the retrogressive?
Chicago, Ill. H. B. C.

The formula to use for determining when a wave winding is progressive or retrogressive is as follows: $k = (K \pm 1) \div p$. In this formula (K) is the number of commutator bars, (k) the lead pitch on the commutator, and (p) the number of pairs of poles.

In any two-circuit wave winding, regardless of the number of poles or whether the bars are odd or even, the above formula will indicate when the wave winding is progressive or retrogressive. It is retrogressive when the minus sign is used and the commutator pitch comes out a whole number, and progressive when the plus sign is used and the commutator pitch comes out a whole number.

For example, take a four-pole, ninety-seven-bar machine: $k=(97+1) \div 2 = 49$, or a lead pitch of 1-and-50. Then $1+49+49=99$, which means that the coils connected in series and starting on bar (1) will have the finish lead connected to bar (99) or bar (2), which is one bar ahead of the starting point. The winding is progressive.

On the other hand, using the minus sign, $k=(97-1) \div 2=48$, giving a lead pitch of 1-and-49. Then $1+48+48=97$, which means that the series of coils starting at bar (1) would have the finish lead connected to bar (97) or one behind the starting point, making a retrogressive winding.

As another example, when the commutator bars are even, take a six-pole 100-bar machine. Then $k=(100+1) \div 3=33\frac{1}{3}$. The commutator pitch comes out a fraction and cannot be used. Then using the minus sign, $k=(100-1) \div 3=33$, or the commutator lead pitch is 1-and-34. Then $1+33+33+33=100$ and the series of three coils starting on bar (1) would have the finishing lead connected to bar (100) or one behind the starting point and the winding would be retrogressive.

In the case of a 200-bar, six-pole machine, $k=(200-1) \div 3=66\frac{1}{3}$, which cannot be used. Then try the plus sign: $k=(200+1) \div 3=67$ or a lead pitch of 1-and-68. Then $1+67+67+67=202$ for a progressive winding.
Wilkinsburg, Pa. A. C. ROE.

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Method of Lining Up Conduit on Ceiling Beams—I wish some reader would please tell me the quickest and proper way to line up ½-in. conduit on the ceilings of mill-type buildings when you are breaking around the beams, using condulet fittings only at the bottom of the beams and also between beams, for lights. Some say it is best to put all of the pipe clips up first by using a chalk line and plumbing down; then you can take the line down and it will be out of the way. Others say to snap the line and take it down, but this method does not make a mark between the beams. As the thickness of the fittings must be taken into consideration, should one go by the edge of the fittings, by the edge of the pipe or by the center of the pipe? Also, should the clips be put up first? If so, what is gained by so doing?
Worcester, Mass. R. S. T.

Replying to R. S. T. in the December issue, common judgment is to be used in a case like this, taking into consideration the physical conditions of the building in question. There being nothing to prevent, a good way would be to string a chalk line across the ceiling, squaring it with the adjacent walls as far as possible. Snap the line, leaving a chalk line mark underneath each beam. Take a hacksaw and cut a small mark on the edge of the beam, deep enough to be readily seen, but without damaging the beam. Rub a piece of chalk over the cut, and it will fill up with chalk, which leaves a permanent mark that will last for several weeks. It is then an easy matter to string a short line from mark to mark, or from beam to beam, as the work progresses, lining up the conduits with a plumb in each bay or section as these are bolted up.

In this method, after the work is laid out there are no long lines to catch on obstructions or be stretched out of true, and your line marks are there for a period much longer than will actually be needed. Try it and be convinced.

Chief Engineer, P. S. PENDER.
Metropolitan Eng. Co.,
Granite City, Ill.

* * * *

Why Can Not This Motor Be Speeded Up?—We have a Westinghouse, type SK, 7½-hp., 1,150-r.p.m., 110-volt motor that is giving us trouble. The nameplate says "Shunt Wound, Continuous Speed," but it has a series field, shunt field and interpoles. For several years this motor ran satisfactorily, until a brush was replaced. The new brush was identical with the old one.

The motor picks up regularly and carries the load, but as soon as the field is weakened to increase the speed the load fluctuates badly; the more the field is weakened the more the load swings until there is a sharp flash at the brushes or a fuse blows. All kinds of connections have been tried, without results. The speed of the motor when running the machine is from 1,150 to 1,500 r.p.m. When the trouble started the machine was running at 1,800 r.p.m. The same trouble occurs with all of the different motors of the same type that we have tried on this machine, although it can be driven satisfactorily by a straight shunt motor of less horsepower rating. Can some reader tell me the cause of this trouble?
Norwood, Mass. E. F.

Referring to the question by E. F. in the November issue, he says that the motor ran satisfactorily for several years until a brush was replaced. I should say that the brush setting was disturbed, as this alone will cause quite a lot of trouble in a motor of this type. He also states that all kinds of connections have been tried without success. If the motor flashes at the brushes or blows fuses with an increase of speed and the load fluctuates badly, it would appear that the fields were improperly connected. If this motor were overfused sufficiently I think he would find that it would come to a dead stop and then start up in the reverse direction, due to the gradual weakening of the shunt field and gradual increase in load due to increased speed, by strengthening the series field and causing it to overcome the weak shunt field, thus making the motor reverse its direction of rotation. I would suggest that he check up the field connections and make sure that the shunt and series fields are connected cumulatively; also see that the interpole polarity for a given pole is the same as the main pole which follows it in the direction of rotation. Then the brush rocker arms should be set so that the coils directly under the interpoles are the coils which are being commutated.
Detroit, Mich. J. J. CONWAY.

* * * *

In reply to E. F's. question in the November issue, it is quite evident that the mere replacing of a brush could not cause the trouble which he describes.

If this motor has operated satisfactorily for several years as a variable-speed machine, it certainly will continue to do so after a new brush has been installed, provided all connections are the same as before.

It is quite evident, from the information given, that the fields do not bear the correct relation to each other for proper operation.

I would suggest that E. F. check the connections again and I am quite sure he will find that the series or interpole winding, or both, are bucking the shunt winding.
Columbus, Ohio. G. B. H.

* * * *

E. F.'s question in the November issue is complicated by the statement that although the nameplate reads "Shunt Wound," the motor has a series field. If the motor really is compounded, the symptoms described would result from trying to run the motor too fast. From the statements made, the motor was running from 30 per cent to 55 per cent over its rated speed, which is stretching the latter quite a bit for a constant-speed motor. Under such conditions the shunt field is so weak that the motor tends to operate as if it were straight series wound. It speeds up until the counter e.m.f. of the motor reduces the armature and series field current to a value which makes the series field weaker than the shunt field. Then the motor slows down and the cycle is repeated until the brushes flash or the fuses blow.

It is stated, however, that this motor ran satisfactorily until a brush was replaced. Is it possible that the brush rocker got shifted while this was being done? If the motor is operated in one direction only, try moving the brush rocker in the direction of rotation. Do this a little bit at a time, say 1/32 in. measured on the face of the commutator. Even a plain shunt, interpole motor will behave as mentioned if the brushes are not correctly placed. But the statement that the same trouble occurs with other motors of the same type would make it appear that the trouble is due to excessive field weakening. Possibly in the years during which the motor was operating successfully it was running at its rated speed of 1,150 r.p.m., since E. F. says that everything is all right until he starts to weaken the field.
Honesdale, Pa. J. M. WALSH.

* * * *

In the November issue E. F. asks for an explanation of a rather peculiar phenomenon occasionally met with in the operation of commutating-pole motors. He is obviously puzzled over the fact that a shunt motor is supplied with a series field, and it may interest him to know that it is put on for the very purpose of preventing unstable operation, which is his trouble.

With the advent of commutating poles there has been a tendency to increase the armature ampere turns relative to the field ampere turns, as there is no longer any need of having a commutating flux fringing off the main pole tip. However, under load the relatively stronger armature increases the distortion of the main field flux due to cross-magnetization, and, as the teeth and pole tips are usually saturated to some extent, the increase in flux on one side of the pole is less than the reduction on the other. The net result is, then, a decrease in total flux per pole, with an increase in armature current.

If the weakening of the field with increasing load is pronounced, the motor speed increases with load and fails to reach a stable point. However, instead of increasing uniformly until the motor flashes over, the speed and armature current frequently oscillate, due to interchanges of energy between the electrical and mechanical systems, the energy being alternately stored as electro-magnetic energy in the motor field and mechanical energy in the rotating parts. To prevent weakening of the motor field with increasing load, the motor is supplied with a small series field and in this case the trouble can no doubt be overcome by adding a turn to the series field.

However, there is another possible source of trouble. If the commutating field is too strong a current circulating in the coils short circuited by the brushes will cause a weakening of the main field with increasing load. Indeed, since in this case trouble commenced after the brushes had been changed, it is probably caused by a circulating current in the coils undergoing commutation. Increasing the commutating pole gap by removing liners from back of the poles, if there are any, or machining a little off the commutating poles, will overcome that difficulty.

A more detailed discussion of the effect of cross-magnetization and the circulating current in the brushes on the motor speed may be had by reference to an article in the *Electrical Journal* for September, 1914, by C. G. Lewis and the writer, entitled, "Speed Characteristics of Direct-Current Motors."

E. F. may be interested in seeing an oscillogram record of the armature current during an unstable condition similar to that which is giving him trouble. He can find such a record in Fig. 10 on page 298 of Vol. XXXVI, of *Transactions A. I. E. E.*, in a paper by the writer entitled "Analysis of Starting Characteristics of Direct-Current Motors." It will also probably interest him to know that the test was made on a motor of exactly the same type and rating, except that it was a 220-volt instead of a 110-volt machine. He will note there that the armature

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current would vary from 100 amps. to 25 amps. in the opposite direction. His motor being of half the voltage and twice the current rating, would, of course, show a much wider variation of current under similar conditions.

Milwaukee, Wis. K. L. HANSEN.

* * * *

Jackshaft Bearing of Mill-Type Motor Leaks Oil.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil.

I shall appreciate it if some of the readers of INDUSTRIAL ENGINEER will give me the remedies they have used to overcome this trouble.

South Chicago, Ill. O. C.

In reply to O. C.'s question in the September issue, without knowing the make of motor, I would say that babbitt bearing linings should not be so long as the bearing housing. Cut them off so that they come, when finished, from ¼ in. to ⅜ in. inside of the bearing housing opening. Also, it is usually very good practice to cut an oil groove from ¼ in. to ⅜ in. in width and a short distance from each end of the babbitt lining, with two or three holes in the bottom half.

The oil ring is placed there for the purpose of carrying oil into the bearing, but it will not carry the oil out; it flows out by gravity. As this bearing has only two openings, one at each end parallel with the shaft, out of which oil can flow, it flows to these openings and then out upon the ground, as it is mechanically prevented from flowing back to the oil well by an obstruction of babbitt extending beyond the bearing housing. If the end of the bearing lining were inside of the bearing housing the oil would drip from the end of the bearing onto that portion of the housing extending beyond the bearing and drain back to the oil well.

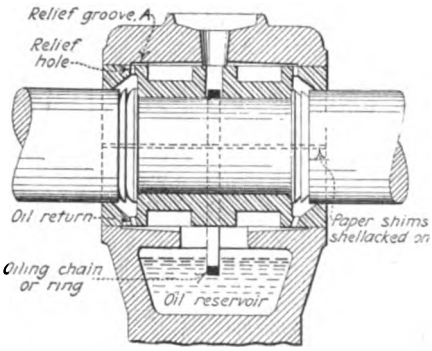
Jackshaft thrust collars were not mentioned, but there should be some form of thrust collar on this jackshaft, two at least, and possibly four. The edge of this thrust collar should carry some form of mist ring or oil thrower; that is, it should not be a flat surface, but of knife-edge design, so as to present the smallest possible surface to which oil can adhere. The oilways cut around the ends of a bearing are put there to provide an outlet from the bearing and the larger the amount of oil one can make flow over the surface of a bearing or shaft in a given length of time, the cooler the bearing will be.

Chief Electrician, A. L. GEAR.
Gary Screw & Bolt Co.,
Gary, Ind.

* * * *

Referring to O. C.'s question in the September issue of INDUSTRIAL ENGINEER, it is somewhat difficult to accurately analyze the cause of the trouble in a leaking bearing without knowing whether the bearing is ring oiled, chain oiled or wick oiled. We will consider that the bearings in question are ring oiled.

The illustration shows a cross-section of a typical bearing arrangement. The oil circulated by the ring creates a pressure which forces it to follow the parting line of the two halves of the bearing toward the outer ends where it clings to the shaft and leaks out. If collars, pulleys, gears, etc., are mounted on the shaft near the bearing, there is a tendency to create a slight vacuum at the ends of the bearing and by reason of the difference in pressure inside the bearing and at its end, the oil is drawn out, leaking down the end of the bearing. Using a heavy oil will not remedy the situation, and will be found to aggravate conditions. Likewise, oil that is thin will flow too freely and leave the bearing in a fine spray.



Shellaced paper shims placed between the bearing halves and a relief groove shown at (A) will prevent oil leakage.

To remedy such leaky bearings a well-shellacked paper shim should be placed at each side between the two halves, so as to close the opening at the dividing line of the bearing halves. Also, if there are no relief grooves in the upper part of the bearing, a groove should be chipped in, extending from the oil-ring chamber to the oil-collecting groove at each end of the bearing, as shown at (A) in the diagram. For general service, a medium oil with a viscosity of 275-310, Saybolt, is recommended. E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Method of Running Open Wiring in Mill-Type Buildings—I wish some of the readers of INDUSTRIAL ENGINEER would give me their opinion on the best way of running open wiring in buildings of mill-type construction. Assuming that No. 8 or larger conductors are used, should these be run on the roof trusses, on the ceiling beams or on the side walls? Should the conductors be supported by cleats or on knobs? What kind of cleats and knobs should be used? I should also like to know when and how strain insulators should and should not be used. Is there any preference as to the type of strain insulator? Any information you can give me will be much appreciated.

Worcester, Mass. R. S. T.

R. S. T. asked, in the September issue, for information on wiring a building of mill-type construction. I would run the wires on either the side walls or on the ceiling beams, depending on which location would require the least work and material. The wires should not be run on knobs or in cleats, as this method is used only where the wire is smaller than No. 8. I would suggest that he use two- or three-wire brackets for supports. These may be fastened to the ceiling beams by means of I-beam clamps or bolts, preferably the former. I have solved many problems of this kind by consulting manufacturers' and jobbers' catalogs, and I believe R. S. T., can secure valuable information if he will obtain some of these catalogs.

Insulators should be used at the termination of each run of wire, and sometimes at each end of the run. They should be equipped with a turnbuckle or eye-bolt. This will provide a means of drawing out of the line any sag that comes after the work is completed. If an eye-bolt is used, it should have several inches of threads and the threads in either the eye-bolt or turnbuckle should be filled with heavy cup grease to prevent corrosion. Any type of insulator that meets the Code requirements may be used, but porcelain is preferable.

I might say that Article 5, Section 501 of the 1923 edition of the National Electrical Code will be very helpful to R. S. T.

Moundsville, W. Va. J. H. BLAIR.

* * * *

In reply to R. S. T.'s question in the September issue, running open wiring in buildings of mill-type construction is largely a matter of conditions, but there are some good rules that may be followed. Assuming that the wires are to be run overhead and that there are no cranes or hoists in the building to interfere, they can be run to advantage on the under side of the trusses by using strain insulators at each end of the line, fastening these insulators directly to the ironworks or bolting a piece of angle iron on the under side of the truss work for use as a dead end.

If there are cranes in the building the only place wires can be safely run is on top of the roof trusses directly under the roof boards. In the case of concrete or gypsum roofs run under the top cross member of the truss work and deaden them as in the first instance. Running feeders on side walls is not done extensively by the open-wiring method. Conduit is best on side walls unless feeders are very large, say No. 4/0 or above. Cleats probably will give better service than knobs in open mill wiring as they are not subject to much breakage, due to their generous size for wires of No. 8 gage or larger. They will also make a very neat job if put up in a straight line and evenly spaced.

It is considered good practice to use strain insulators at the ends of all lines on open work in mills. It is very poor practice to make turns with knobs or cleats when running wires of large size. By using strain insulators, wires may be pulled up tight and they will stay tight, whereas, if knobs and cleats are used the wires cannot be pulled tight and if they are to be kept from sagging a very close spacing of cleats will be required unless strain insulators are used.

There is a decided preference in the kind of strain insulators to be used. In

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buildings where heat and moisture are excessive porcelain insulators are best. If the building is dry, mica or wood strain insulators may be used. They can all be obtained in any variety of styles and voltages which a particular case may require.

Donnacona, P. Q., Can. LEE F. DANN.

* * * *

Answering R. S. T. in the September issue, for running large conductors in mills strain insulators of the mica-globe type, with eyes or clevices, provide the best means of drawing the lines up tightly, where the run is straight. Even where a right-angle turn is desired, strain insulators may be used, fastened back to a near-by wall or to a beam in such a way that each conductor is staggered up or down away from the next one, where they cross or turn.

When using strain insulators for a job like this, provide a turnbuckle insulator at one end of each conductor, so as to take up slack from time to time.

As for the location of the conductors, this depends upon the location of the load; if all or most of it is near the wall keep the feeders near the wall or high up on the wall.

If the greater part of the load is out on the floor, and the girders just over head have a clear runway with no cranes, long, tight lines stretched where convenient can be neatly installed.

If feeders are placed along the side wall, keep them high above the reach of ladders likely to be placed there, as these are a common source of interference. Feeders should be kept high out of the way in all cases, because they cannot be removed very readily for the unexpected installation of some machine, crane or whatnot.

With the lines drawn tightly, large two-piece porcelain cleats taking two screws each may be placed along the line at intervals close enough to keep it from sagging, but the cleats really hold none of the strain.

I have installed many such lines, up to 500,000 circ. mil. diameter, by using globe and turnbuckle strain insulators at each end, pulling the conductors tight first, and then placing large porcelain cleats on either wood beams or on steel girders.

Jamestown, N. Y. H. S. RICH.

* * * *

In answer to the question asked by R. S. T. in the September issue, Article 5, Section 501, Paragraph (K) of the 1923 edition of the National Electrical Code says in part: "In buildings of mill construction mains not smaller than No. 8, where not liable to be disturbed, may be separated about 6 in. and run direct from timber to timber, being supported on each timber only."

In article 5, Section 501, Paragraph (A) the statement is made that supports shall be composed of approved, non-combustible, non-absorptive insulating material, free from checks, rough projections or sharp edges which might injure the insulation on the conductor. If the supports are designed to grip the wires either screws or nails may be used to fasten the support in place, but nails shall be long enough to penetrate the woodwork not less than one-half the depth of the knob and fully the thickness of the cleat. Also, in paragraph (B): "Supports shall provide at least ¼ in. separation between the securing screw or nail and the wire, and shall be designed for two securing screws of the split knob (or single-wire cleat) type intended for wires larger than No. 4."

Personally, I would recommend in your case using knobs screwed in place on each timber, keeping your wires well apart, and if they are in any way liable to mechanical injury, protect them by guard grips not less than ⅞-in. in thickness, and at least as high as your knob. However, for wire larger than No. 6, I would use two-piece cleats secured in position on each timber with two screws. Strain insulators are used at the ends of the runs and unless your lines are No. 4 or larger, it is really not necessary to use them.

Ardsley, Pa. EDWIN V. LAMBERT.

* * * *

Voltage Rating of Fuses for 440-Volt Circuits—Will some reader please advise me as to the proper kind of fuses and fuse cutouts to use on 440-volt, three-phase, 60-cycle circuits? Should I use 600-volt or 250-volt fuses and cutouts? (2) Is it practicable to use fuses above 300-amp. rating as entrance fuses, or would it be better to use a circuit breaker?

Any information that you can give me will be greatly appreciated.

Marion, Ohio. G. R. K.

Referring to the questions asked by G. R. K. in the December issue, 600-volt fuses should be used on 440-volt circuits, because of the inductive effect on alternating-current circuits; 250-volt fuses would not operate satisfactorily. They would be very liable to explode.

As to the second question, it certainly is practical to use fuses above 300-amp. rating as entrance fuses. Entrance fuses burn out very seldom and there could be no possible argument for the use of anything else except a fuse for such service.

Vice-President, H. T. BUSSMANN.
Bussmann Manufacturing Co.,
St. Louis, Mo.

* * * *

In reply to G. R. K., whose question appeared in the December issue, (1) In view of your second question I would use 600-volt fuses in preference to 250-volt; 600-volt fuses of 300-amp. capacity can be purchased and are approved by the Fire Underwriters.

(2) It is practicable to use 300-amp. fuses as entrance fuses; even double that capacity can be used by approval under proper conditions. However, if your service is of such a nature that interruptions due to grounds and shorts are common, the use of fuses would not only be impracticable, but contrary to good practice, due to the cost of fuse replacement and the time lost in replacement, as only competent men should replace fuses of such rating. These men may be at a distance when a fuse blows and the time element involved in looking up the electrician is of consequence. I have installed fractional-ampere circuit breakers on the basis of the labor involved in making fuse replacements and they have proved economical. Another point in favor of the circuit breaker is that when it opens this action is readily discovered, whereas fuses require testing, in many cases to find the trouble. In general a circuit breaker can be reset with the minimum danger to incompetent men, it is readily adjustable to a variety of settings, has no upkeep expense other than periodical testing and cleaning and is less of a fire hazard.

Fuses are cheaper, under conditions that admit of their use, are reliable and require no attention; in many places they cannot, however, be used because of their fire hazard.

If from the above you believe, G. R. K., that a circuit breaker better suits your needs, I would suggest that you get in touch with some of the leading manufacturers of circuit breakers, practically all of whom carry advertising in INDUSTRIAL ENGINEER, state your conditions completely and they will give you costs, sizes and any other information desired.

West Allis, Wis. EDWARD JAMES.

* * * *

In reply to the inquiry by G. R. K. in the December issue, we can advise (1) that the proper voltage of fuses and cutouts to use on 440-volt circuits are those labeled 600 volts. The 600-volt fuses and cutouts are ordinarily used for voltages above 250 and not over 600. For voltages above 125 and not over 250, 250-volt fuses and cutouts are ordinarily used.

The 250-volt fuses are not designed and intended for use on 440- and 600-volt circuits. The 600-volt fuses have a greater break distance and are of a more rugged design than the 250-volt fuses, so as to withstand the added strain to which the higher voltage may subject the fuses under heavy short-circuit service.

(2) Fuses up to 600-amp. capacity, in both the 250- and 600-volt ranges, when made by manufacturers under the approval of Underwriters' Laboratories, Inc., established and maintained by the National Board of Fire Underwriters, will give satisfactory service as entrance fuses, and from the economical viewpoint should be chosen, since they are less expensive than circuit breakers.

Electrical Engineer, J. L. BROYLES.
Economy Fuse & Mfg. Co.,
Chicago, Ill.

* * * *

Answering G. R. K. in the December issue, the National Electrical Code covers the fusing of 440-volt circuits in every detail and all that he can do is to follow these rulings closely, using the necessary judgment as to loading conditions of the circuit. A non-inductive circuit does not require as heavy a fuse as an induction motor load. It is presumed that the circuit feeds a set of induction motors, as is usually the case. The distribution panel from which the circuit receives current is, if designed by a competent engineer, "switched" and "fused" correctly for the purpose for which the circuit is intended.

Whether the load fluctuates greatly, or is steady throughout the daily cycle of service, must be taken into consideration. Induction motors are fused from 110 per cent to 300 per cent of full-load current, depending on the type of starter and the percent of full-load current taken at starting, but under no consideration are they fused over 300 per cent of their rating. Any motor circuit using 300 amp. and above on 440 volts should be equipped with an auto-

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matic circuit breaker, in addition. It is my understanding that fuses can be obtained for all standard ratings.

A good many instances are known where the operators get by with any old arrangement that works half-way, but a first-class job and good construction requires good engineering to begin with, and full protection is the result, not to mention satisfaction to the operators. Manufacturers will supply you with a list of all fuses of standard rating, up to 2,200 volts, and will be glad to furnish you gratis a book or table covering the entire fuse installation.

Chief Engineer, P. S. PENDER.
Metropolitan Eng. Co.,
Granite City, Ill.

* * * *

In answer to the question asked by G. R. K. in the December issue, (1) it is customary to use 600-volt fuses on 440-volt circuits, as the length of the 600-volt fuse allows the arc, caused by the rupture of the fuse, to be extinguished more readily.

(2) If the choice lay between the use of a circuit breaker and the use of 300-amp. fuses, it would be more advisable, from an engineering standpoint, to use the circuit breaker. Although there are in use fuses of larger capacity than 300 amp., it is far more economical, in the long run, to use circuit breakers. In my opinion the circuit breaker is more reliable.

Goldfield, Nev. PHIL D. COMER.

* * * *

Replying to G. R. K. in the December issue, I would suggest that he use 600-volt fuses and fuse cutouts on 440-volt circuits, because 250-volt fuses would be liable, when the fuse explodes, to arc across the terminals where the fuse links are connected.

As to his second question, if first cost does not matter I would suggest that he install an oil circuit breaker with overload relays and current transformers, as service can then be more quickly restored when an interuption occurs. The wiring diagram for the connections can be obtained from the firm which supplies the equipment.

If the circuit is to be metered at this point the power company may be willing to let G. R. K. use the same current transformers that they use for their meters. They would also probably assist him in making the proper connections. If he does not want to use relays he can use an oil circuit breaker with 5-amp. trip coils.

Galesburg, Ill. EARL BABER.

* * * *

Trouble Caused by Plugging Elevator Motor—Will some reader of INDUSTRIAL ENGINEER please give me some help on the following problems? (1) We have a 10-hp., 550-volt, three-phase elevator motor which is controlled by a Cutler-Hammer reversing switch. We are experiencing a good deal of trouble from blowing of fuses due to reversing the motor before the elevator comes to a full stop. This elevator has no regular operator and is used for freight service only. Has anyone had similar trouble and what is the best method of overcoming it? (2) Is it possible to wind a magnet that will lift from 10 to 25 lb. and can be operated on a 110-volt, sixty-cycle circuit? If so, please give me the winding data for 110 volts and also 550 volts.

Millbury, Mass. L. A. T.

In answer to L. A. T. in a recent issue, the reversing switch on this elevator is made by a good company, but it may be either an old type, or of such a type that its motion from low to high speed is not retarded enough, thus allowing a rush of current to blow fuses.

I would suggest, as there is no regular operator on the job, that an oil dashpot be attached to the starting rheostat arm, if possible; or procure a starting speed regulator which includes one. By this means the starting tiller may be pulled to its limit, but the rheostat arm will travel over the contact buttons only as fast as the oil dashpot will permit it to, and it can be regulated to work slow or fast. This simple device will prevent fuses from blowing, or a circuit breaker from opening.

Also, see that the mechanical or electrical brake is tight enough to stop the motor, even when reversed quickly; sometimes there is oil on the brake band, allowing slippage.

I have had exactly the same trouble with an Otis elevator, which already had a dashpot on the controller, but after making proper adjustments all around, it worked satisfactorily.

Jamestown, N. Y. H. S. RICH.

* * * *

Referring to question (1) by L. A. T. in a recent issue, no mention is made of the rating of the fuses used on the equipment. We would suggest checking the size of fuses, as it may be possible that the fuses are not rated high enough. While it is very important not to overfuse the motor, it is well to provide fuses of ample capacity for the service requirements and still give proper protection to the motor. Thirty-ampere fuses could be used for a 10-hp., 550-volt, three-phase, 60-cycle, elevator motor.

If the fuses are rated as above we would suggest checking the general operation of the equipment, including the brake settings, so as to be sure that all details are correct and functioning properly. Buttons on the shipper rope or some other means of centering the reverse switch may help matters considerably.

As to question (2), it is possible to wind a magnet for 110 volts, 60 cycles, that will lift 10 lb. to 25 lb., but it is practically impossible to give any definite winding data to obtain this result, as this depends largely upon the general design and efficiency of the magnet. In the design of an a. c. magnet laminated iron should be used to reduce the eddy currents. The plunger can be designed to have an area of 1 sq. in. for every 8 lb. to 10 lb. pull, while the coil should be approximately 2½ times the length of the stroke and the stop should extend in the coil about ¼ of its length.

There are a number of manufacturers listing a. c. magnets and it may prove a saving to L. A. T. to purchase one of these standard magnets. The Cutler-Hammer Mfg. Co. list a. c. magnets in their catalog under Bull. 10345. The windings used on one of these standard magnets designed for 30-lb. pull at 2-in. stroke on a 110-volt, 60-cycle circuit consists of 180 turns of No. 9 d. c. c. wire. The resistance is 1/3 ohm, and the coil length 4¼ in. For 550 volts, 60 cycles, the coil consists of 900 turns of No. 16 d. c. c. wire, resistance 3.2 ohms.

W. J. NEUSTEDTER.
Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

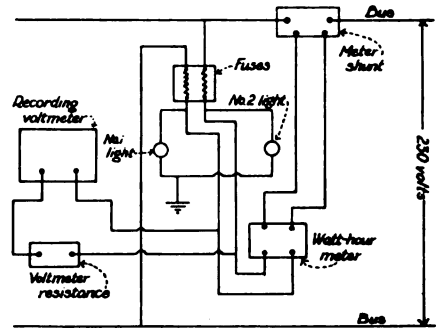
Trouble with Switchboard Instruments—The diagram shows a section of our switchboard with which we are having considerable trouble. The watt-hour meter slows down and the recording voltmeter registers 180 volts when the voltmeter is put in circuit. However, the watt-hour meter runs normally when the recording voltmeter is cut out of circuit. I removed the voltmeter and found it tested O. K., as does the watt-hour meter.

No. 2 light on the ground indicator burns at full brilliancy on account of a ground on the meter circuit, which can not be traced out because the plant operates 24 hrs. a day. No. 1 light does not burn.

When a test light is put across the voltmeter terminals, with the voltmeter cut out of circuit, it burns dimly as does No. 1 light on the ground indicator.

Can someone tell me what and where the trouble is?

Iola, Kan. G. E. G.



In reply to G. E. G. in the December issue, I would like to know whether he tested the voltmeter resistance when he tested the voltmeter. His sketch shows it as external to the instrument and I believe that he will find it the weakest point in that circuit. It is more than likely that his trouble is in the voltmeter circuit, either in the leads to the voltmeter or in the resistance. Very likely it is in the resistance as this is prone to breakdowns from many causes, such as vibration, foreign matter, etc.

A ground in this circuit or resistance could also account for the No. 2 light burning, which would not necessarily affect the wattmeter except that it would record the consumption of more energy than was being used. This extra energy would be that which is lost through the ground circuit.

No. 1 light would not burn in this event because the circuit is completed only through the voltmeter and when so completed the high resistance within and without the meter would not allow enough current to pass to light No. 1 light, for as G. E. G. notes, when the meter is disconnected and a test light placed across its terminals No. 1 ground light burns dimly, due to the fact that not only are the two lights in series, but the external voltmeter resistance and the ground of unknown resistance are also in series.

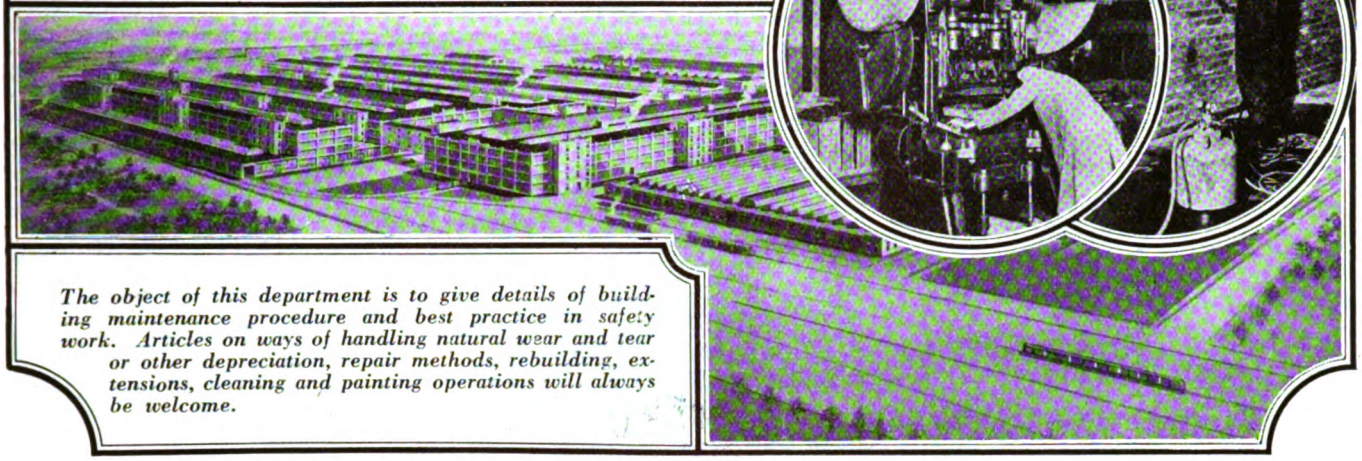
The voltmeter reading of only 180 volts is due to too high resistance in the circuit, but it is possible to figure the value of this resistance as follows: $230 \div vmr = 180 \div x$, where 230 equals line voltage, vmr equals internal and external voltmeter resistance, and 180 equals indicated voltage. This problem would be an interesting one to work out and the answer may make shutting down the plant a matter of economy.

If I were G. E. G. I should certainly investigate this meter circuit, with particular reference to the resistance.

West Allis, Wis. EDWARD JAMES.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Charting Frequency of Making Inspections of Equipment

AT the recent annual meeting of the National Safety Council, C. B. Auel, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., in his paper on, "Accident Records, and How to Keep Them," emphasized the need of adequate accident statistics. In this work, he stated, there are four kinds of records which should be considered. These are: (a) Number of Accidents; (b) Accident Frequency; (c) Accident Severity; (d) Causes of Accidents. But little can be accomplished toward the reduction of accidents without knowing what is the cause of them and also how severe are the accidents which are caused by the various hazards.

In addition to these four records, which he considered the absolute minimum which should be maintained in intelligent accident prevention work, Mr. Auel pointed out that there was another set of records which should also be kept if accidents were to be reduced to the minimum. In this, he emphasized particularly a calendar of things to be done regularly in accident prevention work, which consists of a list of safety meeting dates and dates of inspection of various items throughout the plant which must be kept up if accidents are to be avoided. Without having some regular specified time to make these inspections they are frequently overlooked, or the period extended beyond what might be considered a safe time. Such a calendar would include specifically the items shown in the accompanying table.

Inspection Periods for Equipment

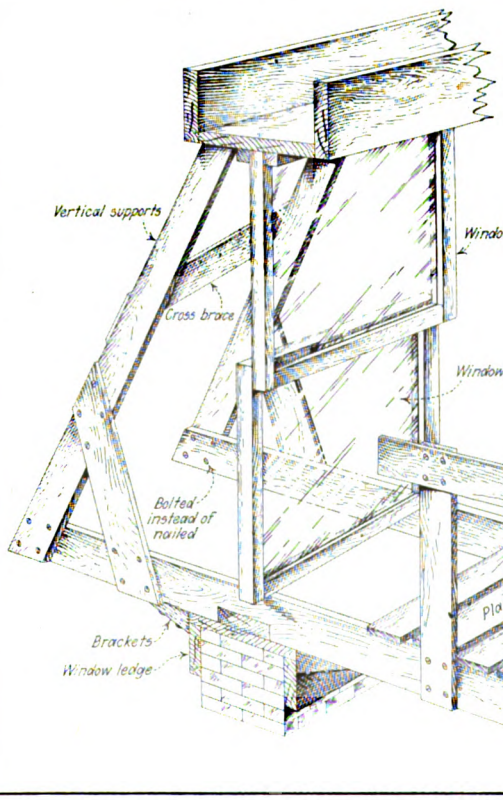
Period	Items
6 mo.	Hand trucks.
6 mo.	Ladders—portable and stationary.
6 mo.	Window cleaners' belts and window eyes.
6 mo.	Stretcher cabinets.
Weekly	First-aid cabinets.
Daily	Cranes, hooks and chairs.
12 mo.	Crane operators } Physical
	Food handlers } examination.
6 mo.	Hand tools including pneumatic tools.
Daily	Elevators.
12 mo.	Hydraulic elevator trucks.
6 mo.	Electrical hazards.
3 mo.	Machine tool guards.
3 mo.	Safety meetings.

Making a Portable Window Cleaning Scaffold

VARIOUS types of window cleaning and repairing scaffolds are in use, some of which are dangerous while others have a large margin of safety. The construction which is used in one large office building, as is shown in the accompanying sketch, involves sound mechanical principles and is safe. The fixture is detachable and is put up without fasteners or bolts. It is handled entirely from the inside of the building and is lifted through the opening after raising the lower sash. After the window washer has gone outside the bottom sash may be closed.

The platform is fitted with a safety guard rail about 2 ft. high and is constructed entirely of wood, with bolts holding the joints together. The vertical sections sustain the main load and as these are loaded as a column, the danger of breaking is decreased.

Washington, D. C. G. A. LUERS.



This portable window scaffold is safe and strong. This type of scaffold can be used to advantage where there is no sill to stand upon or no place to attach a safety belt.

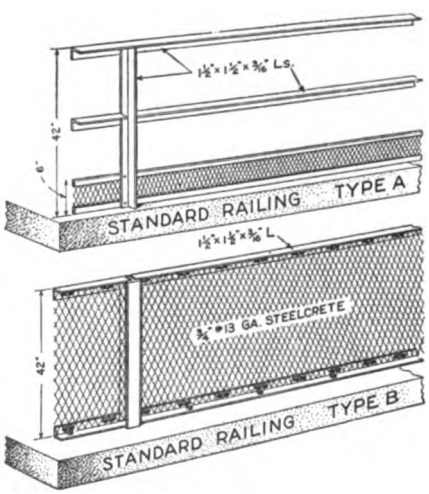
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Construction Details of Various Standard Railings

IN THE construction of a practical machine guard, strength and conformation with the regulations of the Compensation Insurance or State regulations, should be the primary considerations. State regulations vary somewhat and so should be consulted for each particular location. These regulations govern the distance from the guard to the object guarded, the height of the guard and other similar factors. Strength is important, as a poorly built guard will soon rattle itself to pieces. In any case, a guard should at least be strong enough and rigid enough to stand the weight of a man resting heavily against it. It always pays to construct guards substantially because when this is done the guards will last as long as the machine.

One common type of guard is what is known as the Standard Railing. The construction of two types of standard railings, as recommended by the Consolidated Expanded Metal Company, Braddock, Pa., is shown in the accompanying illustration. Most specifications give a standard railing as 3 ft. 6 in. high, built of 1½-in. by 1½-in. by 3/16-in. angles, with uprights spaced not more than 8 ft. apart. This may be filled with ¾-in., No. 13 gage mesh as at (B), or may be provided with additional railings between the top rail and the floor as at (A). In such a case, a toeboard is necessary. This may be constructed of a strip of sheet metal or of ¾-in., No. 13 gage mesh standing up from the floor to at least a height of 6 in. and run continuously around the edge of galleries, balconies and floor openings to prevent small objects from falling over the edge. These toeboards should be used around all floor openings, elevated runways and platforms, 6 ft. or more from the floor level.

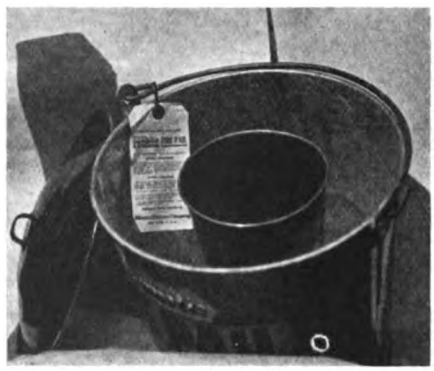
There are, however, some exceptions. For example, they are not needed on small platforms for motors, fans and other similar equipment unless there is an 18-in. width of standing room. Also, they may be left off on oiling runways built only for oiling or repairing shafting, belts and similar equipment if the runway is 18 in. or more in height and has a standard railing on one side. Toeboards are not required on runways used only for giving access to monitor roof windows. Neither is a standard railing required on platforms used for loading freight on cars or trucks.



The construction of two types of standard railings, such as are used around floor openings, elevated runways and platforms.

Organization of Fire Prevention in Industrial Works

EXPERIENCE has shown that practically all fires can be extinguished within three or four minutes if found early enough and if proper equipment is brought into use by men who know how to use it.



The solutions are kept in separate compartments and mix to form a frothy solution which smothers the fire when thrown on it.

Sound fire prevention principles are taught to the men in charge and they are held responsible for the observance of all fire prevention measures by their men. To encourage neatness, monthly plant inspections are made and a banner presented to the most orderly department. The most untidy department is awarded a broom with appropriate wording. This work was first organized in 1917 and put under the control of the safety engineer.

The first piece of equipment received was an "emergency wagon." This carried four 2½-gal. Foamite extinguishers, sand pails, "Y" branches, two shut-off play pipes, 150 ft. of 1½-in. factory hose, 50 ft. of standard hose, two 65-ft. lengths of ½-in. rope, crowbar, axe, two shovels, smoke respirators, gas, hydrant, spanner and monkey wrenches, hose washers and other equipment. This wagon is the first to respond to all fires and is manned by four firemen especially trained in chemical fire fighting. It carries sufficient equipment to put out most fires.

Another piece of equipment is the "equipment wagon," which carries boots, helmets, coats and other supplies. Thus some firemen are enabled to go from work directly to the fire instead of stopping at fire headquarters for their equipment. Other firefighting equipment consists of two 500-ft. hose reels, two 300-ft. hose reels, six fire houses and a Model "D" 40-gal. Foamite engine. In addition, all buildings on the company's grounds are equipped with a sprinkler system and in addition, Foamite, soda-acid, and carbon tetrachloride extinguishers. Especially hazardous locations are also covered by "fire depots," which consist of a solid wood back mounted on the wall with a shelf supporting two Foamite fire pails as shown in the accompanying illustration. A framed set of fire rules is placed between the brackets just underneath the shelf and just below this two Foamite 2½-gal. extinguishers are suspended with a carbon tetrachloride extinguisher between them. While these depots protect extra-hazardous locations, they are placed at a safe distance from the risk so that they will not be involved should a fire occur. The construction of one of these fire pails, which shows how the two solutions are kept separate, is shown in an accompanying illustration.

The location of fire protective devices is carefully pointed out by a system of sheet-metal indicating signs. These have a white background with red lettering reading, "Fire Extinguisher," "Fire Depot." The small end points directly in line with the extinguishing device.

The fire organization consists of a chief, assistant chief, battalion chief, five captains, 23 men, and a fire equipment inspector, who is the only man in uniform. He is responsible to the chief for refilling extinguishers, for care of fire houses, looks after the daily plant inspection, sees to the elimination of inflammable materials, maintains clear aisles, prevents smoking and looks after the enforcement of all fire rules and protection in general. Weekly fire drills keep the members in constant practice. Each member of the fire department is thoroughly trained in artificial resuscitation and in conveying prostrate persons either up or down ladders. One night protection feature lies in the fact that all watchmen are instructed in fire prevention and protection and carry a tetrachloride extinguisher.

K. P. BABCOCK.
Fire Chief and Safety Engineer,
Gilbert & Barker Mfg. Company,
West Springfield, Mass.



One of the Fire Depots used in hazardous locations.

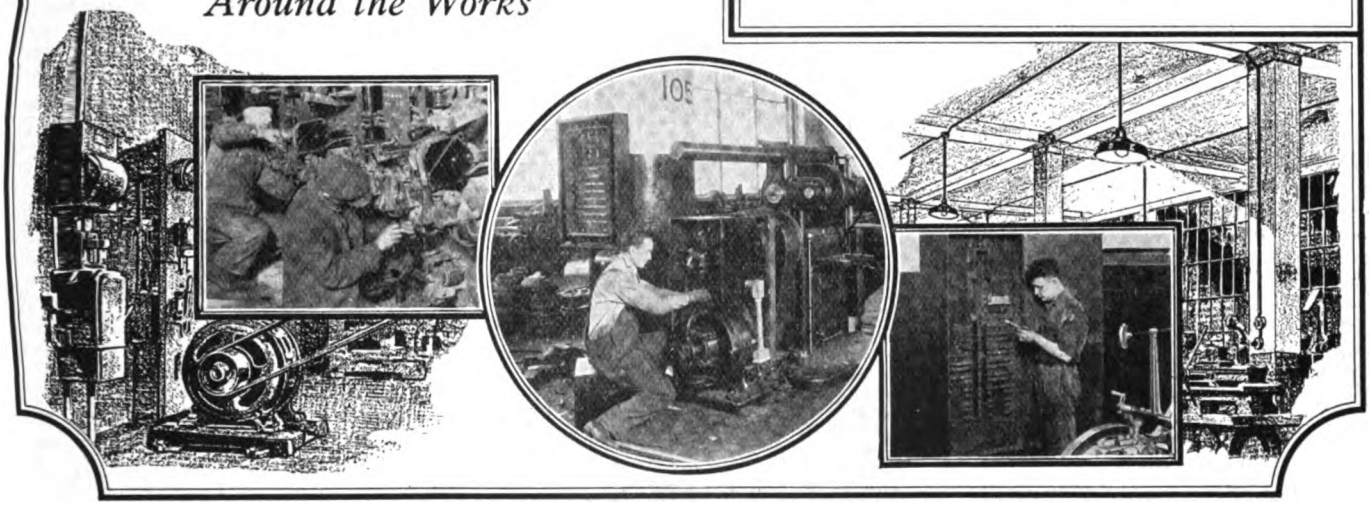
As an extra precaution several of these Fire Depots are placed near oil containers and other special hazards. These depots consist of a shelf with two fire pails containing Foamite solutions, two 2½-gal. Foamite extinguishers and a carbon tetrachloride extinguisher.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Safety Device for Stopping Crane at Point of Small Clearance

OCCASIONALLY operation of the bridge motion of a crane presents a hazard to workmen repairing equipment which has a small clearance beneath the crane. The crane operator is usually intent on watching the load he is carrying, and mentally maneuvering the spotting of the load, and in consequence cannot be depended upon to observe workmen who might be swept off or crushed against equipment presenting insufficient clearance. Also, the men, intent upon their own work, could hardly be expected to devote their time to watching for the crane.

In one instance a small bucket elevator cleared the bridge girders of a 5-ton crane by about one foot. The drive mechanism was at the top of the elevator, and workmen frequently had to go up there to oil, inspect and repair the mechanism. To minimize the danger as much as possible means were sought to prevent the crane operator from approaching the elevator without receiving some warning when men were working around it.

The crane was equipped with an overhead trolley using a short pole for carrying the harp and wheel. It was decided to put a trolley-type section insulator in one of the trolley wires on each side of the elevator. These insulators were placed far enough from the elevator so that the crane after passing the section insulator, and thus having the power cut off, would almost coast to a stop before reaching the elevator. The feeling of the power being shut off instantly calls the crane operator's attention to the danger zone and he would almost immediately apply the brakes and stop the crane.

The section of trolley wire which was arranged to be made "dead" through the section insulators was supplied with power through a safety switch capable of being locked by individual padlocks which were carried by the mechanics and oilers. The manner of connecting in the safety switch is shown in the accompanying diagram.

Any trolley-sectionalizing device may be used; in this instance, a Westinghouse Type HM, Style No. 127358, insulator was used. Means were provided for fastening it to the lower chord of the roof truss above the crane, as shown in the diagram. The section insulators were placed in the positive trolley wire only, for the circuit was permanently grounded on the negative side as power was also furnished for traction service. The crane rail was not used for a ground return as the sparking on the rails was objectionable and created disturbances on the plant telephone system.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Minn.

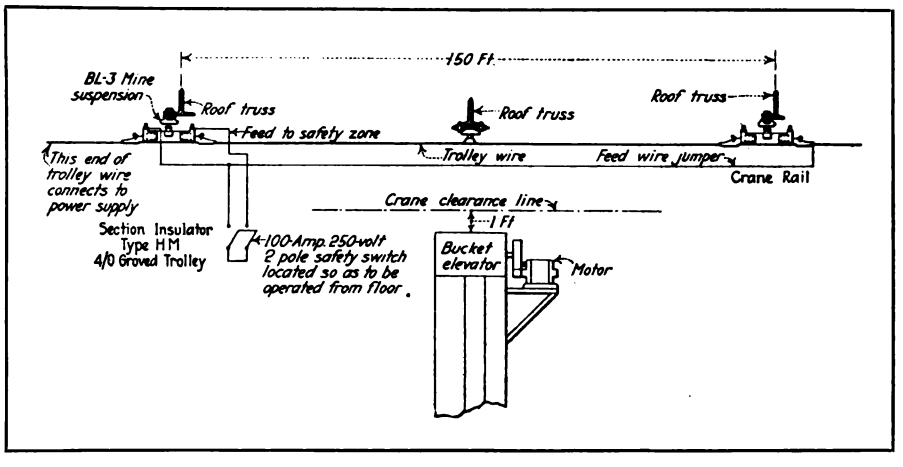
The crane trolley wire adjacent to the elevator was sectionalized by two section insulators.

The sectionalized portion was supplied with power through a safety switch, as shown. When men are working on the elevator the switch is opened; hence power for the crane is shut off as it approaches the elevator, thus preventing injury to men on the elevator.

Trouble Caused by Failure of Test Lamps to Show Open Fuse

IN a paper mill which is driven by two-phase motors, one entire department recently had an unusual experience as the result of a blown fuse. Without warning or other indication of trouble, several motors suddenly stopped while others continued to run. It was found that the motors which had stopped could not be started. An electrician made a hurried test of all branch fuses, using lamps as indicators, and found that all branch fuses tested O. K. The lamp test was then applied to the main feeder fuses and these in turn tested O. K. However, the motors which were running still had a peculiar hum, indicating an open phase.

The foreman accordingly pulled the main feeder fuses and opened them. He found one fuse blown, although the lamps had indicated voltage across all phases. The back-feed or regenerative action of the polyphase motors had caused sufficient voltage to exist across the open phase to light the lamps, although the fuse was open. After this experience, the foreman instructed the electrician to open any suspected fuses or to make sure that no polyphase mo-



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tors were connected at the time the lamp test was made. Failure of the lamps to indicate the true condition of the fuses caused a delay of more than an hour in the department affected.

Power Engineer, DEAN W. TAYLOR.
Central Indiana Power Co.,
Indianapolis, Ind.

Portable Compensator Unit for Emergency Use

IN most industrial plants operated by electric motors, it is customary to keep several motors and a few spare compensators on hand for emergency use. By mounting a compensator on a skid platform, as shown in the illustration, and bolting to it a couple of supports for a safety switch, one can with little work assemble a portable unit which can be quickly moved by the aid of a lift truck to any department of the plant.

The switch and compensator are connected up after being mounted. The leads connected to the top of the switch and to the motor terminals of the compensator are left long enough to reach any compensator switch when the portable unit is located conveniently close to it. The ends of the six leads (for a three-phase outfit) have terminals soldered on so that in case of a breakdown of the transformer or other part of a compensator requiring more than a few minutes to make repairs, the portable unit can be quickly connected up and put into service.

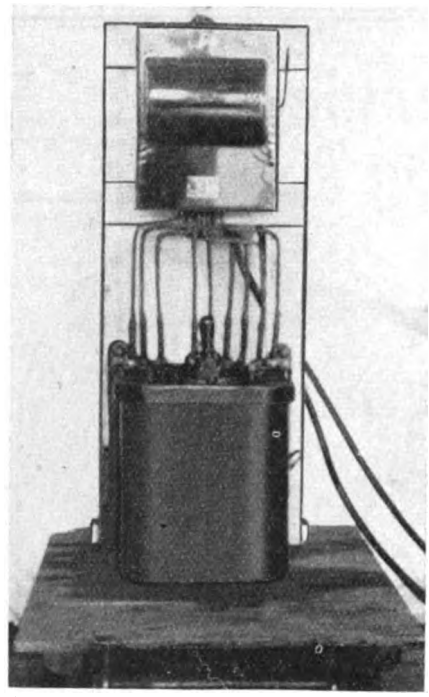
The switch or line leads of the portable unit are usually connected ahead of the switch blades of the disabled compensator switch, and the motor leads of the unit are connected to the conductors leading to the motor. Thus a motor can be put into operation again in a very few minutes without the trouble and consequent delay of taking down the disabled compensator and installing a new one.

As the disabled compensator is disconnected from the motor circuit repairs can be made on the spot or the compensator can be removed to the repair shop, as the case may require.

Of course, one unit of this kind will not handle all sizes of motors but usually one compensator will operate motors several sizes smaller than its own rating and one unit can thus be used with four or five sizes of motors.

Wearing parts of compensators are kept on hand but occasionally an unexpected breakage occurs and it is found that that particular part is not stocked. A portable compensator unit can then be used until new parts can be obtained, thus avoiding loss of production.

Chief Electrician, J. F. MORGAN.
Mercury Mills, Ltd.,
Hamilton, Can.



A broken-down compensator can be replaced by this portable compensator-and-switch unit and service restored in a few minutes.

Platform for Mounting Electric Welding Equipment

AT the Chicago plant of the Brunswick-Kroeschell Company, three arc-welding sets are used. One of these sets is portable and is moved around the plant, as needed. The other two remain in the welding department where the work is brought to them. Instead of placing the equipment on the floor in the usual manner, the substantial arrangements, shown in the two accompanying illustrations were used.

A steel bench about 3 ft. high was constructed large enough to take all of the equipment for one welding set. The legs and supports of the bench were made from ¼-inch by 2-in. angles, the cross members of ¼-in. steel bar and the top of the bench of ¼-in. steel plate.

The illustration at the left shows the location of the motor-generator set and the cabinet containing the switches for varying the resistance. The illustration at the right shows the location of the push button for starting the set and also the cabinet containing the starting apparatus, as well as the enclosure for the stabilizers, shown at the extreme right. Note the racks on which the electrode cables are wound when the equipment is not in use.

The idea behind the whole installation was to have all parts accessible and convenient for inspection and maintenance and at the same time to protect them as much as possible from the dirt that they would be subjected to if placed directly on the floor.

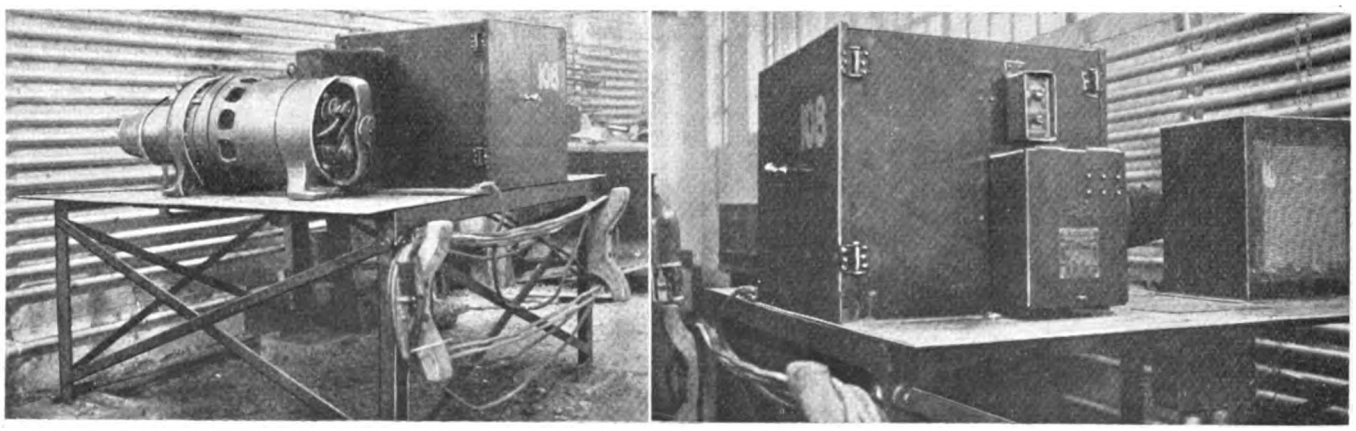
The electric welding equipment mounted on this platform is accessible for inspection and maintenance, and is kept away from the dirt on the floor.

Generator and Storage Battery for Arc Welding

IN A foundry where some of the 200-lb., semi-steel castings come through with a few holes and slight cracks, it was thought advisable to try to arc weld them instead of throwing them back for scrap. As an experiment a No. 00 conductor was clamped to the casting and connected to the positive side of a 100-amp., 110-volt, direct-current switch on a storage battery charging panel. The 3/16th-in. steel welding rod was attached to one end of the negative lead and the other end was connected to the positive post of the panel switch.

This charging panel also carries a current-regulating, gridiron rheostat which was set for 60 amp. when the arc was playing, with the line voltage at 110-volts. However, it was hard to maintain the proper arc at this current value so the rheostat was adjusted to 70, 80 and even 90 amp., but still unsatisfactory results were obtained.

The voltage of the generator was then lowered to 90 volts and the amperes again regulated to 60, 70 and



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90 amp., but still the arc would not play steadily and caused a good deal of delay in welding.

A twenty-cell battery of the Edison A-6 type was handy, having been on charge for some hours; so the welding leads were connected to this battery instead of to the generator line. The arc was much easier to maintain, but it was found that the voltage dropped before many minutes. Then we tried using a 50-gal. barrel of water containing sal soda and sal ammoniac with two iron plates for electrodes and connected in the generator line on 110 volts. This arrangement worked fairly well, but the arc was still unruly.

Finally, the leads were connected again to the storage battery which was floated on the generator line at 110 volts, and with the rheostat set at only 70 amp. the arc now holds remarkably steady. Once in a while the negative rod "freezes" to the casting and immediately gets red hot right up to the operator's holding pliers. The meter meanwhile registers not over 90 amp.

With this final arrangement, scores of large castings are being welded every week. The operator protects his face and eyes by ruby- and violet-colored glass, mounted in a light wooden frame held in one hand. This allows him to glance quickly at the flaw in the casting after it has been welded, as it is impossible to see some of the holes and cracks by looking through the shield.

A canvas glove is used on the right hand as the steel welding rod and pliers get very hot at times. Spare rods are kept handy and can be quickly bolted to the lead.

The conductors are attached to the battery terminals by large copper lugs which are slotted for quick handling. Copper lugs are also used at the other end, one at the clamp which is fastened to the casting and one at the welding rod. One end of the rod is bent in a small loop so that it can be bolted to the lug.

The battery terminals are quite large and are located at the ends of the containing cases or trays so that it is easy to connect copper lugs to them. Leads 12 ft. long are used so as to get at a safe distance from the battery, which gases fiercely when on overcharge. The gas given off is easily exploded by a stray spark, as we have learned by experience.

Besides castings, many other things such as tools and broken machine parts can be quickly welded, as it is easy to get the welding rod into any corner or any other out-of-the-way place.

This outfit is not used steadily; so the battery can, without difficulty, be kept charged. The results obtained by welding have been so satisfactory that it is planned to install a standard portable welding outfit in the near future. However, the arrangement described above has served its purpose well.

New Britain, Conn. H. S. RICH.

Safety Device For Killing Live Trolley Wire When It Breaks

MANY cranes use collector or trolley wires for the power supply to the bridge and trolley motors instead of the bars or angles which are now more widely used. Trouble is sometime experienced with the trolley wire breaking and the live ends coming in contact with workmen or material, thus grounding the wires and possibly causing some damage or injury. The purpose of the device described in this article is to kill the power supply on a trolley wire as soon as it breaks.

The device is located at the end of the trolley wire at which power is delivered. A ball insulator and turnbuckle are fastened to the eyebolt (A) and to the trolley-wire support. The trolley wire is fastened to eyebolt (B) and tension is applied to the trolley wire so as to compress the spring to the position shown in the drawing. This brings the copper block (C) in contact with the flat-iron strips forming the sides of the device. The power supply is connected to the terminal screws (E).

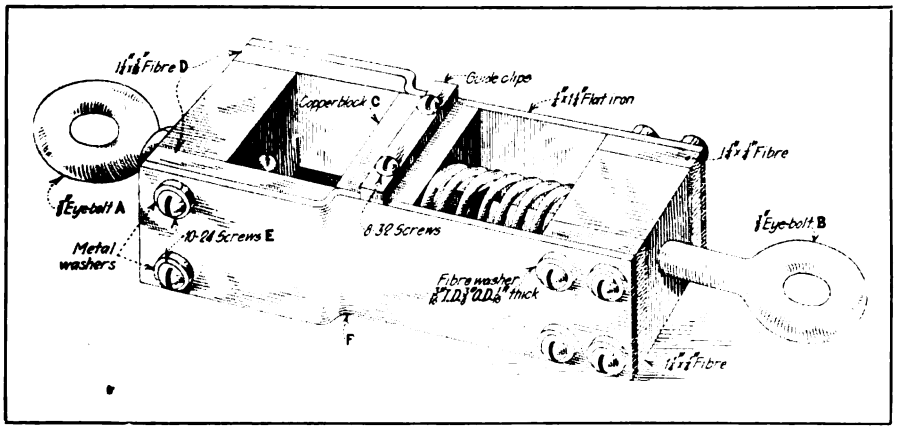
With tension on the trolley wire so that the spring is compressed, the current will flow from the line to the terminals through screws (E) through the flat-iron sides to copper block (C), through eyebolt (B) to trolley wire. If the trolley wire breaks the compression spring will force the copper block (C) towards the eyebolt (A) and the copper block will be insulated from the flat-iron sides by the fibre strips (D). Hence the trolley wire is dead and there will be no danger of electric shocks from touching it.

The device can be readily made from material at hand in any electrical repair shop. The accompanying drawing gives the details of the material to be used. In making up the device it is important that the separator, through which the eyebolt (B) passes and to which the flat-iron sides are bolted, be insulated by the two fibre blocks, as shown in the drawing.

The separator which holds the eyebolt (A) need not be insulated, but if it is, it does away with the need of a strain ball insulator, for the eyebolt (A) would then be insulated and could be attached directly to the support. In case the separator which holds the eyebolt (A) is not insulated, it will be necessary to place a fibre block so as to prevent the copper block (C) from striking this eyebolt and its separator; otherwise contact would be made between the block (C) and the line, after the trolley wire had broken. This fibre insulator may be fastened to the copper block (C) or to the separator which carries eyebolt (A).

Detroit, Mich. O. E. BRICKER.

This device is a good safety feature for cranes using trolley wires. Power is applied at *E* and travels through the metal sides of the device to the copper block *C*, thence to eyebolt *B*, to which is fastened the trolley wire. If the trolley wire should break the tension on it would be released and the spring in the device would force the copper block *C* towards eyebolt *A*, and block *C* would be insulated from the metal sides by the fibre strips *D*. Hence both ends of the broken trolley wire would be dead.



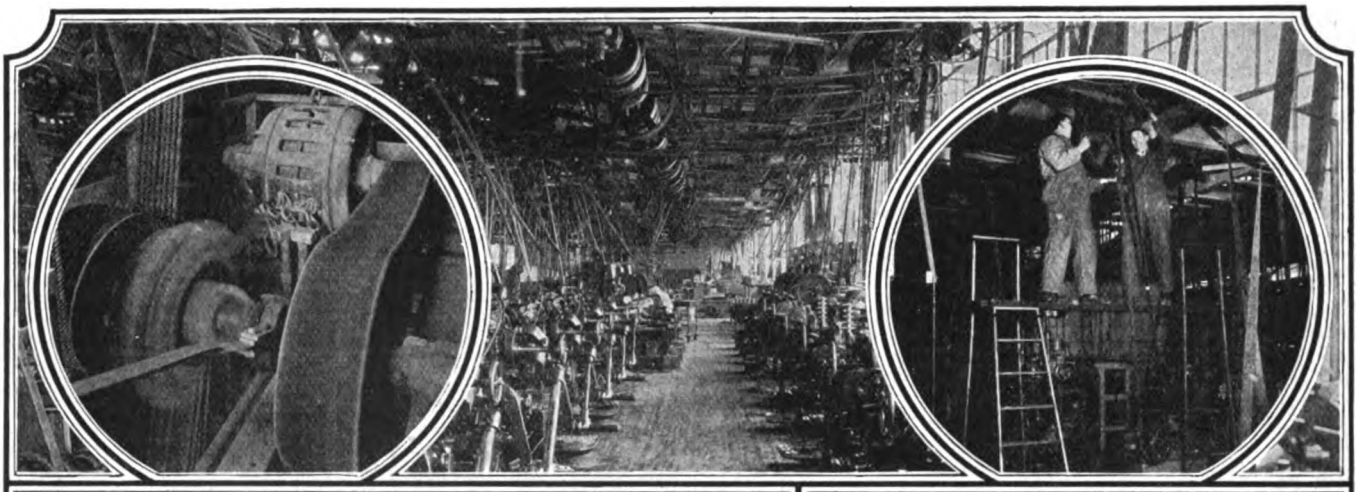
Advantageous Applications of Two-Speed Motors

IN MANY industrial plants there are motor applications that call for more than one motor speed. Where the duty of the motor is more or less continuous, the merits of the two-speed, squirrel-cage motor may well be considered in comparison with those of the variable-speed, slip-ring motor. A common application of this class of motors is in driving ventilating fans. Often it is felt that very sensitive control is required for fan motors, but in many cases the chief requirement is the ability to operate efficiently under heavy or day duty and light or night duty. In many such instances the light-duty speed does not have to be any particular value and does not need to be as great as for regular, heavy duty. Under these circumstances the two-speed, squirrel-cage motor excels the slip-ring motor.

At half-speed the two-speed motor has practically the same efficiency as at full speed, while the slip-ring motor efficiency at half-speed is generally less than half the full-speed efficiency. It follows that where half-speed is sufficient for the duty required, the two-speed motor will be more than twice as efficient as the slip-ring motor. Very often the period of light duty is longer than the period of heavy duty. In this case the superiority of the two-speed motor is of still greater importance. In addition to its greater efficiency over its speed range, the two-speed motor will generally be cheaper to install and less expensive to maintain than will the slip-ring motor.

Power Engineer, DEAN W. TAYLOR.
Central Indiana Power Co.,
Indianapolis, Ind.

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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Determining Combined Efficiency of Elements of Hoisting Mechanisms

WHEN designing hoisting machinery for handling heavy weights at low speeds, it may be necessary to use several gear reductions and 12 or more parts of cable. If the slide rule is employed to calculate the efficiency of this mechanism there is considerable danger of error in multiplying the same number several times; therefore, in order to save time and reduce the number of errors, the writer has made up and uses the accompanying table, which has been found very convenient. This table was calculated on the slide rule, as this gives results which are sufficiently accurate for the purpose.

The following example will illustrate the method of using the table: What is the over-all efficiency of a headgate hoist with 4 reductions of gearing and 12 parts of cable, assuming an efficiency of 0.94 for each gear reduction and 0.98 for each pair of sheaves? From the table the fourth power of 0.94 equals 0.78 and the sixth power of 0.98 equals 0.885; therefore, $0.78 \times 0.885 = 0.69$, which is the combined efficiency of the mechanism.

Montreal, Can. WM. L. LAING.

Method of Securing Co-operation of Operators When Making Speed Changes

IN these days, everything industrial is being speeded up. Machine operators sometimes kick about this and try to find weak spots in the results. But every department head who reads his engineering paper, who goes around a bit, who listens as he should to the salesmen who drop in—every such person knows that new machinery that will run faster should be put in, or the existing machinery speeded up. The latter is the easier and less expensive method, but it runs up against that adverse personal element more than does the former. How shall it be brought about in the most effective way? This problem is of importance to executives, industrial engineers, mechanics, millwrights, and foremen.

One hustling machine shop has been through all of this. It has made money. The same machines are running twice as fast as they were ten years ago. The men seem to be used to the change and they are getting out a proportionate amount of work. There are 80 machine tools in this shop, kept in good condition, and the shop is meeting competition in a manufacturing line even though there is little capital available for new machines. The way it has been worked is applicable to other plants and is worthy of detailed consideration.

There were several metal planers in the shop. In the days when Joshua Rose's "Complete Practical Machinist" was the one book of the trade, a cutting speed of 15 ft. or 18 ft. per minute was considered proper for planing. This shop's planers were belted to that standard. The shop's new executive had the lineshaft pulleys changed to bring these up to 20 and 22 f.p.m. The men got along all right, in fact, rather enjoyed the change, for there is a lot of tedious waiting in doing planer work.

A year later, a change in motor pulleys jacked this speed up another 5 ft. a minute. With the changes which time works in the personnel of a shop new men were taught to run planers, and along with this the superintendent took occasion to still further increase the speed, until today the planers are running at 40 f.p.m. and all concerned take that speed for granted. Once, during the stepping-up process of later days, there was a concerted complaint of the machines running too fast to properly watch the tool, whereupon the men were taken to a motor truck factory in the same city and given a peep at a planer running on aluminum crank cases at 75 f.p.m.; needless to say they came back satisfied.

In drilling, much the same plan of gradually increasing the speed was followed out. It is always easier to get men to remember that, for instance, a ½-in. drill should be run on the third step of the pulley than to remember it is to cut at 80 ft. a minute. The tendency is to err on the slow side of this rather than on the fast, and by changing the main shaft pulleys the actual speed for each step of the cones was increased just that much. Today, 1-in.

Table for Combining the Efficiency of Mechanisms

Number	N^2	N^3	N^4	N^5	N^6	N^7	N^8	N^9	N^{10}	N^{11}
.99	.98	.97	.96	.95	.94	.93	.92	.91	.90	.89
.98	.96	.94	.92	.905	.885	.866	.85	.833	.815	.80
.97	.94	.913	.884	.86	.833	.806	.783	.76	.736	.715
.96	.92	.885	.846	.815	.782	.75	.72	.691	.663	.636
.95	.903	.856	.815	.773	.736	.698	.665	.632	.60	.57
.94	.884	.83	.78	.732	.688	.646	.608	.576	.542	.508
.93	.865	.804	.748	.695	.645	.60	.558	.518	.482	.448
.92	.846	.779	.716	.659	.606	.567	.513	.472	.435	.40
.91	.828	.754	.685	.623	.566	.515	.468	.426	.388	.353
.90	.81	.729	.656	.59	.531	.478	.43	.387	.348	.314

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drills are being run as fast as ½-in. drills were five years ago.

On manufacturing work that uses drills smaller than ½ in. the change to high-speed drills was made long ago, but under the former management the machines had remained at the same belted speed and the benefits, some of them, from the superior steel, were realized only if the speed change on the machine itself was shifted to its fastest speed. Usually it was not. The new regime put on pulleys that were too fast for high-speed steel, with the result that on the lower speeds, where the boys were likely to run them, the speed was just about correct. Not long ago a battery of six milling machines came in for attention. Whereas a decade ago they were running at a spindle speed of 100 r.p.m., they are now doing from 220 to 280. In speeding up these milling machines, all the work was done out of hours—usually over the week end—and so the operators knew nothing of it. These were single-speed, single-purpose machines and the work was of such a nature that a straight count of the number of pieces done per day did not tell the men anything about their output; the men were day workers, and quality was stressed more than anything else.

In this way, greater output was secured without friction in the shop. Had the men seen the changes in pulleys and belts, they would have inwardly rebelled. As it was, one machine at a time was changed over and no one was the wiser. The results secured went a long way toward meeting the increased costs of doing business, including higher costs for materials and wages, and the like.

This same shop made its own tools and jigs and one of the machine tools employed on this work was a 16-in. shaper. All the men who had used this machine "found" that a one-tooth feed was the highest permissible for good work. There were five feed changes on the machine, made by shifting an eccentric and dropping a spring pin in any one of five holes. One night the foreman plugged the first hole and now they get along just as well and do as perfect work with a two-tooth feed as before with the one.

What has been done in this machine shop can be done in others and can be done in other lines, whether it is the cement business or textiles or printing. The main thing is to read the trade papers and the best books and learn from them what advances others are making—then try them for yourself, in your own way on your own particular machinery. Old machinery can be speeded up remarkably high. The writer is not one of those who believes that "they don't make as good equipments now as they used to," but he believes that where you can't get new machinery you certainly can get more out of the old.

The co-operation of the men running machines is necessary in any plan of greater production. Oftentimes, a good deal of coaxing and explanation and driving is necessary. Where the work is not physically hard, men on a day wage are seldom putting forth their highest efforts and so a certain amount of speeding up can be done honestly without going into a discussion. An instance of this fact was noted recently in a wood-working plant. Thirteen men had been kept busy making window blinds and they were always behind the rest of the mill work. A change to piece work was made and now one man and a boy take care of all requirements nicely.

As has already been said, the best time to change speeds is over night or during week ends. Do all the work, including placing the belts on the pulleys and picking up odds and ends; better still, start up the power and run a trial piece or two. If the plant is shut down for a week, that is a good time to re-speed machines or departments, the latter being done by installing larger motor pulleys. DONALD A. HAMPSON.

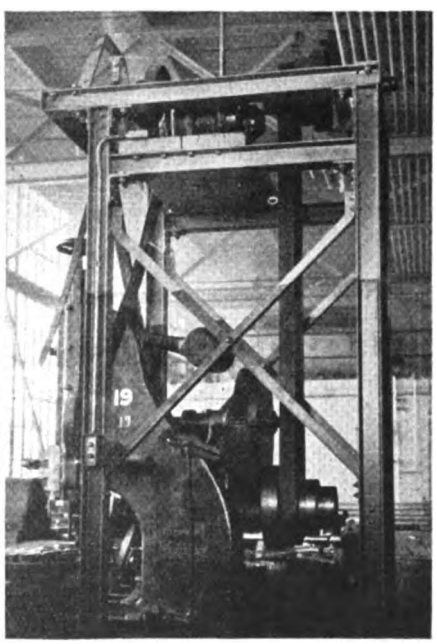
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Taking Advantage of Belt Slip As Safety Link in Machine Drives

SOMETIMES industrial men complain because belts slip. However, if belts are of the correct tension and capacity for the load and overload conditions, slip is not a serious factor. Under some service conditions the ability of the belt to slip under special conditions, is a distinct advantage. For example, in the slotter drive shown in an accompanying illustration, the belt slips and finally runs off the cone pulleys when the slotter sticks because of an extra heavy feed or other cause.

Originally, the motor was connected to this slotter by chain. A few days later, the operator accidentally brought the ram down on the piece and something had to break. The countershaft and cone pulleys were then added and give adjustable speed in addition to a safety link against a similar mishap.

When machines, such as this which operate under conditions where they may be stopped suddenly or be heavily overloaded, are to be driven by chains it is almost necessary to insert a safety pin in the sprocket which will break when the load is applied but before endangering the sprocket or chain.



The belt driving this slotter serves as a safety link in that it will slip and run off the pulley in case of stoppage or an overload.

Chicago, Ill. E. D. F.

Operating Heavy-Duty Lineshafts On Ball Bearings

FREQUENTLY service conditions on lineshaft hanger bearings are so severe that considerable difficulty is experienced with ordinary bearings. Such a case occurred in the main lineshaft drive at the plant of C. V. Hill & Co., Inc., Trenton, N. J., manufacturers of refrigerators and store fixtures. As this is a woodworking plant the machinery and lineshaft are operated at a speed which is higher than the average for most industries. The 3 7/16-in. shaft is driven at 330 r.p.m. by a 24-in. double belt from a 150-hp. engine.

The most severe conditions here are due to the fact that the shaft is mounted on a brick wall on bracket hangers and adjustable, self-aligning hanger boxes. The wall does not have any strengthening supports and bulges during operation due to the high tension maintained on the belt. This throws the shaft entirely out of alignment.

After considerable trouble with other bearings, Fafnir double-ball, self-aligning transmission bearings and hangers were installed. Where previously the oiling had required careful and frequent attention the new bearings received only two oilings in 18 mo.

Narberth, Pa. STANLEY D. BERG.

Static Electricity Cause of Shocks to Oilers

RECENTLY I was called upon to trace the cause of shocks which the oilers received when they worked around an automatic bottle machine. I tested from the machine to ground for defects, thinking that perhaps one of the seven motors on the oiling system on the machine was defective. This investigation failed to disclose any defects; so I decided to watch one of the men while he was oiling different parts of the machine. I found that he reached through a blast of steam coming out of a ¼-in. nozzle at 60 lb. pressure, which is used for cooling certain parts of the machine. I found that it was while reaching through the blast of steam that he received a shock.

To test out my theory that static electricity was the cause of the shock, I attached a wire to an oil can and tied the latter to a dry stick. The end of the wire was held a short distance from part of the metal work of the machine, to form a spark gap to ground. When I held the oil can in the steam blast there was a continuous rain of sparks, caused by the static electricity generated by the steam blast on the oil can.

After the oilers were instructed to turn off the steam while oiling the machine, no further trouble was experienced. L. E. BENEZE.

Chief Electrician,
Illinois Glass Company,
Alton, Ill.

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This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Inexpensive Outfit for Locating Defects in Armatures

FOR testing armatures we use in our shop an outfit that is quite efficient and very cheap to make. It consists of two dry cells, an ordinary buzzer and a telephone receiver. For the sake of protection and convenience in handling, the batteries and buzzer are enclosed in a box. Two leads each about 3 ft. long are brought out from the box and as will be seen from the illustration a single-pole switch is cut into one of the leads so that the circuit may be broken as desired, or when the outfit is not in use. The insulation is skinned off for about an inch at the ends of the leads, which are fastened to a piece of strong cord.

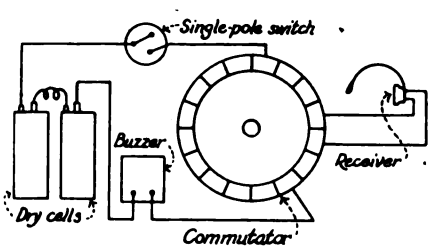
In use, the cord is tied around the commutator to be tested and the points separated about 10 or 20 bars, depending on the resistance of the coils and the number of bars in the commutator. The leads of the telephone receiver are then placed on adjoining bars between the points and the character and intensity of the buzzing sound is noted in the receiver. Each pair of bars between the buzzer points is then tested in succession.

If all the bars sound alike, the armature can safely be relied upon to run. If a low sound, or no sound at all, is obtained, a short-circuit is indicated. A sound which is louder than usual indicates an open circuit between the two bars. A crossed or transposed lead will sound like a shorted coil: that is, it will give either a low buzz or no buzz at all. A grounded coil can be located by putting one of the receiver leads on the shaft and then moving the other from bar to bar and noting where the sound is lowest. The bar that has the lowest sound is usually connected to the grounded coil.

A shorted or grounded coil in a stator can be located with a buzzer by touching the ends of the buzzer leads to the leads on the stator and then testing the individual coils in the same manner as the bars on the commutator.

We find this method of testing to be about as accurate as the use of a millivoltmeter or other testing instruments; at the same time, it is generally easier and quicker than most other methods. This outfit has the further advantage that it is light and easy to carry and, therefore, convenient for outside jobs.

Peoria, Ill. GEORGE E. RINGNESS.



Method of using a buzzer and a telephone receiver for testing armatures.

Emergency Method of Thinning Commutator Slotting Cutters

COMMUTATOR slotting cutters used in a certain repair shop were of two different thicknesses 0.025-in. and 0.040-in. respectively. The supply of 0.025-in. cutters became unexpectedly exhausted and the prospects indicated serious delay in production before any more could be obtained. A few of the 0.040-in. cutters were thinned by holding them against the side of an emery wheel with a pair of pliers, but the results were very unsatisfactory because the teeth varied in thickness in different places around the circumference of the cutters. Eventually another emergency grinding method was adopted.

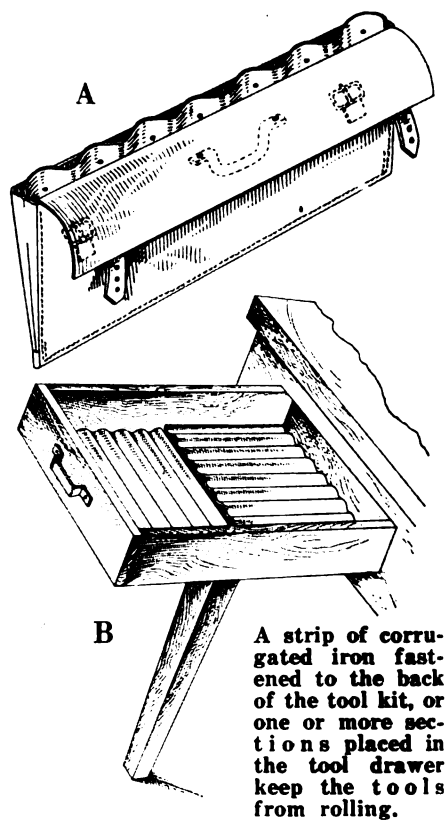
A piece of hardwood rod, such as is used for making dowel pins in the pattern shop, was obtained. The cutter was slipped over the end of the rod and the latter pressed against the side of an emery wheel with the left hand; by means of a wooden stick in the right hand, the cutter was also pressed against the wheel. By trial a point of application of the stick to the cutter was found where the cutter could be made to revolve slowly and thereby continuously present a new surface to the emery wheel. At first, unconscious relaxation of hand pressure on the wooden rod frequently would permit the cutter to fly off the rod into the catch pan under the wheel, but a little practice overcame this.

It took about three minutes to reduce an 0.040-in. cutter to a fairly uniform thickness of 0.025-in. and in thinning 12 cutters it was necessary to use about 9 in. of the wooden dowel rod.

Brooklyn, N. Y. J. A. HORTON.

Corrugated Iron Used to Keep Tools in Order

SIMPLE and convenient means of keeping small tools arranged in an orderly manner and easy of access will usually save their cost many times over. Small strips of corrugated galvanized iron can be used for this purpose in several different ways, at little or no cost. For example, a strip of any convenient length may be nailed or screwed to the wall above the bench and a variety of small tools slipped into the pockets formed by the corrugations. With this arrangement, it is a simple matter to keep the bench from being littered with



A strip of corrugated iron fastened to the back of the tool kit, or one or more sections placed in the tool drawer keep the tools from rolling.

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tools, and yet these are always within sight and easy reach. If a narrow strip of wood is nailed close to and underneath the corrugated iron, drills and the like may be kept in the pockets.

Again, a very handy tool kit may be made from heavy canvas with a strip of corrugated iron fastened inside at the back, as is shown in (A) of the illustration. In this case also, screwdrivers, chucks, drills and so on may be placed in the corrugations and thus kept separate but easily located. In use the kit is tipped slightly and the tools slide forward, making the selection of the desired tools easy.

A third use of corrugated iron is in the bottom of tool drawers, as shown in (B). Two sections placed in the bottom of the drawer are most convenient. A piece for long tools, placed lengthwise of the drawer at the rear, and a crosspiece in the forward section for small tools, will be found very convenient in keeping the tools in orderly arrangement, as they will be prevented from rolling from one end of the drawer to the other or from side to side when the drawer is opened or closed.

Washington, D. C. G. A. LUERS.

Essential Construction Details of A. C. Magnets

CONSTRUCTING a good a. c. magnet is a problem that seems to puzzle many mechanics and engineers. A good deal has been written about magnets, but it is rather strange that books often give page after page of details about pull, number of turns, size of wire and the like, without mentioning the far more important mechanical requirements for making a good a. c. magnet.

In constructing such a magnet, the first and by far the most important thing is to get the mechanical parts right and the rest can be worked out with a little experimenting, if the right size of wire or the right number of turns cannot be figured correctly the first time. If the magnetic circuit or mechanical construction is wrong the magnet will remain wrong no matter how many coils are tried on it to make it quiet or operate satisfactorily.

The horseshoe-type magnet is by far the most common. In this type of magnet the armature is generally hinged so that the effective pull is nearly all on one leg of the magnet. A typical magnet of this kind is shown in (A) of the illustration. The core of the magnet as well as the armature is made up of sheet-iron punchings or laminations to keep down the eddy current or core loss. As the current reverses in all a. c. magnets the magnetism must also reverse and if there were no other means for holding the magnet closed during the reversal the magnet would start to open up and then close again as the magnetism built up again in the opposite direction. As this reversal of magnetism takes place 120 times a second on a 60-cycle circuit, the periods when there is no pull are so short that the magnet could not really open much, but a very disturbing noise will be produced. To overcome this noise or humming the surface of the active pole (the pole farthest away from the hinge) is given as perfect a fit as is possible with the armature, generally by grinding but quite often by scraping after the grinding. Where the magnetism crosses this joint some form of a shading ring which can be in the form of rivets, a copper, brass or iron ring or a wound coil, depending upon the size of the magnet, is placed as near the surface as possible in either the armature of leg of the magnet so as to cover at least half of the pole area. The function of this coil or ring is to make the magnetism that passes through the coils lag behind the magnetism that goes past the coil in such a way that when the magnetism that passes the coil reverses that passing through the coil is still continuing due to the current induced in the coil. As this magnetism dies down within the section of the pole covered by the shading coil it also changes from passing around the entire magnet to forming a local circuit or small whirlpool as shown in the illustration and holds the armature down long enough for the magnetism in the rest of the circuit to build up in the opposite direction until it is strong enough to hold the armature down. There is, therefore, a constant magnetic pull greater than that required to keep the magnet closed.

If the electric circuit is broken just before the current reverses, there will be enough residual magnetism left to make such a magnet stick badly, even though it is built of soft iron or steel punchings, if the proper air gap is not provided somewhere in the magnetic circuit. This air gap is nearly always placed between the armature and the leg of the magnet nearest the hinge. This gap need not be over 0.005 in. to kill practically all the residual magnetism but it is generally two or three times that amount to insure against wear. It is very important that this air gap be not bridged by any iron hinge or other iron mounting. Therefore, the hinge should be made of nonmagnetic material such as brass. It might be mentioned here that the short magnetic lines set up around the shading coil during the reversal of current have no noticeable sticking effect. Where rivets are used to hold the punchings together, as is generally done, they must be so placed that none of them form a closed circuit with any of the rest through which current can be induced. That is, all the magnetic lines of force that pass on the inside of one rivet must also pass on the inside of all the rest, unless the rivets are insulated, which is seldom necessary. For that reason, rivets in both armature and horseshoe parts are all placed along the center line as indicated in the figure. However, they should all be placed at the outer edge or all near the inner edge, but never staggered nor in a double row, or some of them would have to be insulated.

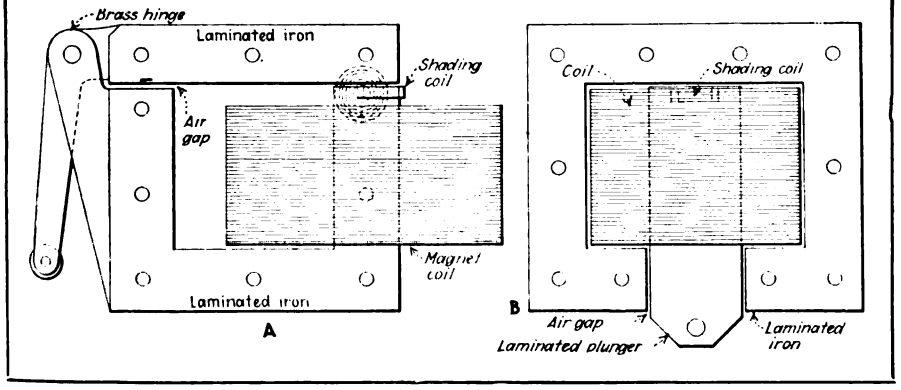
The hinge of such magnets should be well fitted and rugged. In many cases the laminations of both parts are riveted to a heavy center piece of brass that also forms the hinge while in cheaper magnets it is a heavy sheet steel punching with a brass bushing. Side plates are not quite as desirable from the electrical standpoint as the center mounting but may be a little easier to construct.

Unlike d. c. magnets, resistance tubes should not be used in any a. c. magnet that requires energy to close because when the magnet is open the impedance is low and any resistance that would materially reduce the voltage on the magnet when it is closed would practically absorb all the voltage that the magnet would get when it was open and, therefore, there would be no pull on the armature. The closing power, especially in the plunger type of magnet, is entirely different in an a. c. magnet from what it is in a d. c. magnet. With an a. c. magnet it is much greater when the magnet is open than in the case of a d. c. magnet, while it is less when the magnet is closed. This is due to the much heavier wire used in the a. c. magnet, which allows it to take a very heavy current while open, the current decreasing rapidly as the magnet closes, due to the higher impedance. The current in a d. c. magnet coil, on the other hand, depends entirely on the resistance and is the same when the magnet is open as when it is closed, while the magnetism increases from a very weak field when the magnet is open to a very strong field when the magnet is closed. The pulling power is, therefore, low until the magnet is very nearly closed.

In (B) of the illustration is shown a typical a. c. plunger magnet, the shading coil being in the top of the plunger, which is grounded, as is the inside upper part of the magnet frame. An air gap is provided where the plunger is guided on the edges of brass plates as it passes through the lower part of the magnet.

PHILIP G. BERNHOLZ.

East Orange, N. J.



Details of horseshoe type, A, and plunger type, B, a. c. magnets.

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Electrical Devices in Power Service

(*Continued from page 83*)

made. The object in making a new design was to obtain a lighter and more easily handled piece of apparatus. The advantages of the new outfit over the old one are that it is considerably lighter, and more convenient to handle.

Meters and Relays.—Rectangular-shaped, switchboard meters have been placed on the market by the Weston Electrical Instrument Company of Newark, N. J. This company informs us that this type of meter as compared to the old round-pattern type results in a space saving in the ratio of five to nine.

The Roller-Smith Company of New York, N. Y., informs us that it has brought out three new lines of switchboard meters, some intended for use on direct current and others for alternating current. This company has also developed a new portable, alternating-current, ammeter and voltmeter, which it has added to its extensive line of meters.

Clock improvements on its line of graphic meters are reported by the Esterline-Angus Company of Indianapolis, Ind. Some of the intermediate gears in the driving mechanism have been eliminated thereby reducing lost motion and friction. The company further states that in order to make the works of the clock more accessible for inspection and cleaning, the metal cover which fits between the side plates is now made removable, so that by sliding this plate out, the entire train is exposed and accessible for any oiling or maintenance that might be required.

A type NT amperehour meter has recently been placed on the market by the Sangamo Electric Company of Springfield, Ill., which is designed for use on electric automobiles, trucks, mine locomotives, industrial tractors, and the like, where severe conditions of operation are likely to be encountered. Installed on the vehicle, truck or locomotive, the meter indicates by means of a black hand the amount of battery discharge that has taken place. By comparing the position of this hand with a red hand located at the point where the battery should be recharged, the operator can tell what remaining capacity is available before the battery should be put on charge. This guards the vehicle from being stalled when at a distance from a battery recharging station.

When the vehicle is placed on charge the Sangamo amperehour meter automatically gives the battery the proper overcharge and opens the charging circuit at the proper time, thus eliminating the need for attendance.

A maximum demand regulator for reducing peaks and power demands on electric systems has been developed and placed on the market by Edward T. Moore, electrical engineer, Syracuse, N. Y. The regulator is designed to limit the amount of power taken by any energy-consuming device and is especially intended for use with large loads such as electric steel-melting furnaces, annealing and heat-treating furnaces and pulp-wood grinders, as well as motors and other equipment. It is said that the regulator may be set to limit any power load to a predetermined amount, may be used for any length of demand period and may be changed as desired. A graphic meter or integrating meter may also be used in connection with the regulator.

Miscellaneous.—In congested installations it is often difficult to install the usual type of disconnects equipped with mounting base. To meet this condition a bus type of switch designed to clamp directly to the bus bar, has been developed by the Delta-Star Electric Company, Chicago, Ill. Blades can be set in line with, at right angles to the bus, or in any intermediate position that may be needed to fit the installation requirements.

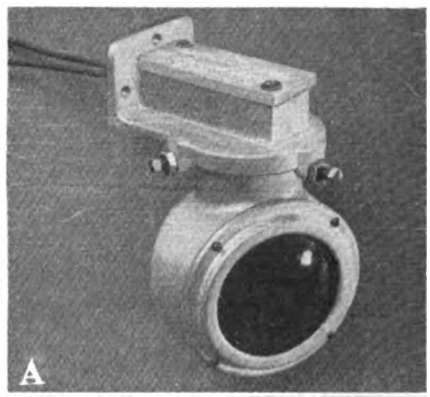
Bus spacers are desirable when buses are so installed that short circuits will subject the bus bar to a cantilever pull. The tensile and compression strength of bus supports are greater than the cantilever strength but by installing bus spacers the cantilever pull on the supports will be practically neutralized. A new type of bus spacer has been designed by the Delta-Star Electric Company, Chicago, Ill.

A new bus support has been designed by this company for supporting bars of high ampere-capacity. It is said to have an ultimate strength of 60,000 lb. against short circuits between phases. With this support the phase conductors are separated into two parallel sets of bars, reducing induction and heat and increasing the ampere-carrying capacity per square inch over that secured with the conventional ¼-in. spacing between bars.

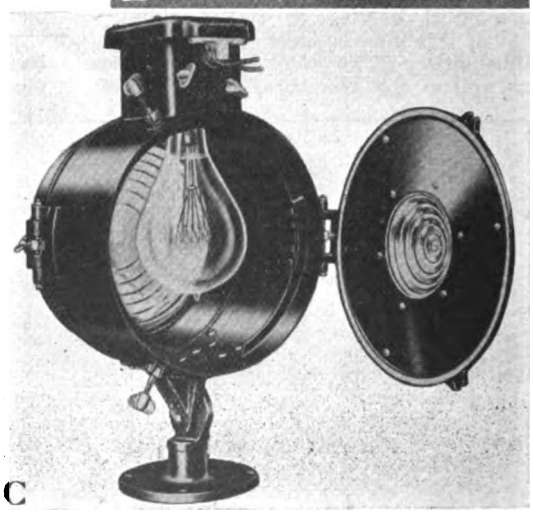
An inclosed primary disconnecting switch for use in vaults ahead of the oil circuit breakers on circuits of 4,400 volts and under in capacities from 100 amp. to 400 amp. has been placed on the market by the Line Material Company, Milwaukee, Wis.

Well lighted yards not only increase the amount of work done but are also safer for workmen.

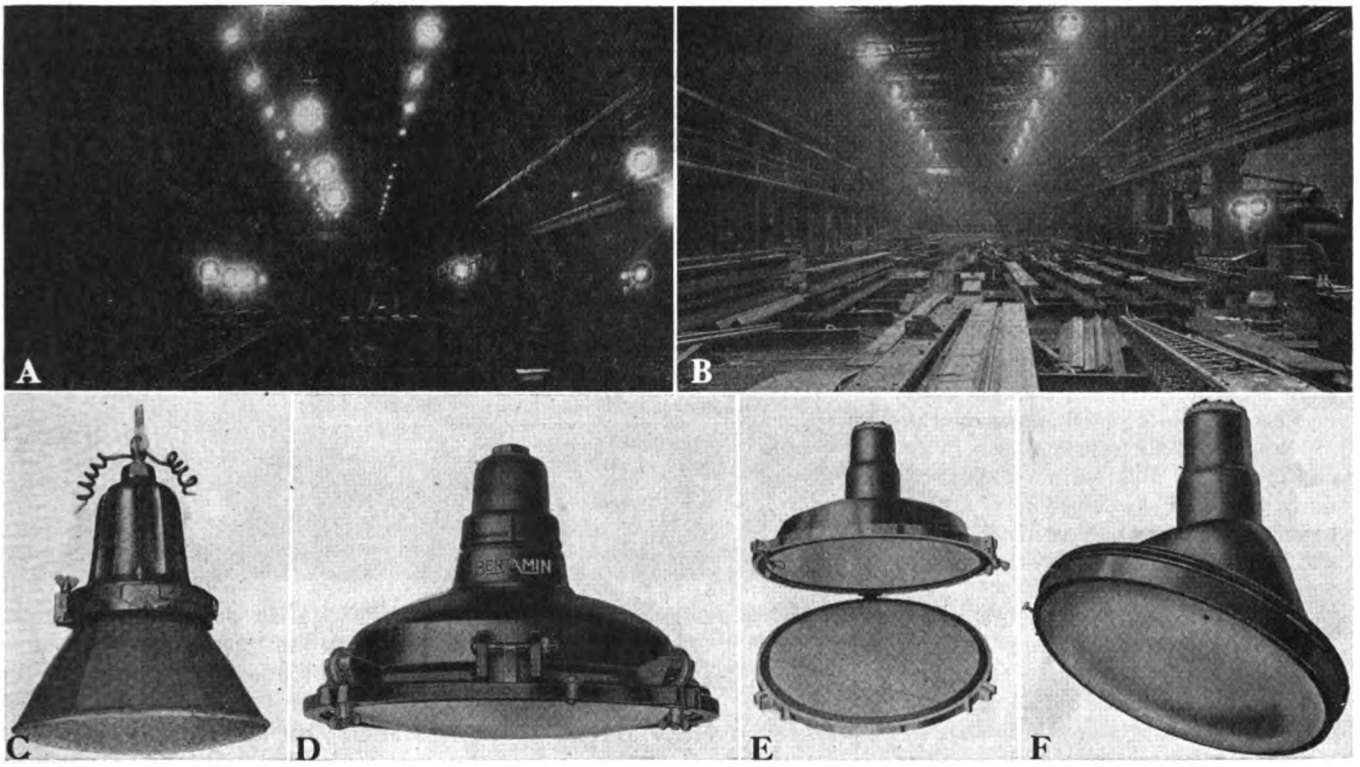
At *B* is shown a floodlight projector made by the General Electric Company. At *C* is one made by the Crouse-Hinds Company of Syracuse, N. Y. Both have been especially developed for the dirty, dusty service of steel mill and railroad yards. At *A* is shown a signal light made by the Nichols-Lintern Company of Cleveland, Ohio. It is made of aluminum and said to be able to stand severe outdoor and indoor service.







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Industrial reflectors that have been developed to cope with the dirt and smoke found in many industrial plants.

At *A* and *B* are shown views "before and after installation" of the High Mounting Height Units made by the Holophane Glass Company, Inc., of New York, N. Y. It is pointed out that these units are particularly adapted for use when the lighting units must be installed at a considerable height, as over a crane runway. *C* is a new dustproof reflector made by the General Electric Company. The globe is made of one piece of glass, the sides of which are silver plated and covered with a coating of copper. *D* is a dustproof cover shown attached to a standard R. L. M. reflector unit. Both are made by the Benjamin Electric Manufacturing Company of Chicago, Ill. *E* is a dustproof lighting unit developed by the Ivanhoe Division of the Miller Company, Cleveland, Ohio. The maker points out that cleaning this unit is simply a matter of wiping off the glass plate on the bottom of the unit. *F* is another dust-tight unit developed by the same company for use where the reflectors are inverted or at the side of the structure to be lighted.

Industrial Heating

The continued growth in the use of electric energy for industrial heating purposes was evidenced by an average increase of about 15 per cent in the amount of equipment of all classes produced, is the report received from the General Electric Company.

This company further states that the volume of miscellaneous forms of heating units for application to process machinery was about the same as for 1923, while equipment for industrial ovens for baking japan, foundry cores, and the like was somewhat less.

The most marked increase was in connection with electric furnaces for heat treating and vitreous enameling; the production of this type of furnace showing an increase of approximately 70 per cent over previous demand.

The American Metallurgical Corp., Boston, Mass., has put out a 20-kw., 220-volt, single-phase, electric pot furnace for use in cyanide, lead, or salt hardening and white metal melting. The maker states that the efficiency and the absolute temperature control of this furnace have made it possible for the manufacturers of small tools and parts to produce a quality which is impossible in a fuel-fired unit. The manufacturer further reports that the heat-resisting containers will last indefinitely, as the electric heat never reaches a point where overheating is possible owing to a protecting gold fuse which is inserted between the heating elements and which protects the elements if anything should go wrong with the automatic control instruments.

The manufacturer of Globar, a non-metallic type of resistor used for electrical heating, has changed its name from the Wireless Resistor Company to American Resistor Company. This company, which is located in Milwaukee, Wis., reports that it has improved the process of manufacture so that greater uniformity of the resistor element has resulted. The maker also states that improved types of terminals and supports have been developed for use with this heating element.

Industrial Lighting Equipment

Reflectors and Projectors.—One of the main developments in industrial lighting equipment is the construction of dust-tight units that protect the reflecting surface from discoloration, dirt and corrosion caused by the dusty and smoky atmosphere found in many industrial locations.

Among the recently developed lighting units is the dust-tight equipment made by the Ivanhoe Division of the Miller Company of Cleveland, Ohio. The manufacturer reports that by protecting the inner surface of the reflector with a glass plate sealed with copper gaskets, not only is the efficiency of the reflecting surface retained, but protection for the lamp and electrical connections is also provided. Cleaning then becomes a simple matter of wiping off the glass plate. This unit is shown in one of the accompanying illustrations. This company has also developed dust-tight floodlighting units and protective covers for reflectors inverted below or at the side of the structure to be lighted. These protective covers, which are shown in an accompanying illustration, are

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designed to keep rain, snow, or dirt away from the lamp and inside of the reflector.

The General Electric Company has developed a new dustproof unit for industrial plants. It consists of a cast-iron top with a felt globe seat. The globe is all one piece of glass, the sides of which are silver plated and covered with a coating of copper. The bottom is clear rippled glass. The manufacturer states that this unit is very efficient and at the same time it is not hard on the eyes because of the rippled glass on the lower part. This unit is shown in an accompanying illustration. This company has also developed a weatherproof projector, which utilizes standard 110- or 220-volt, 300- to 1,000-watt lamps.

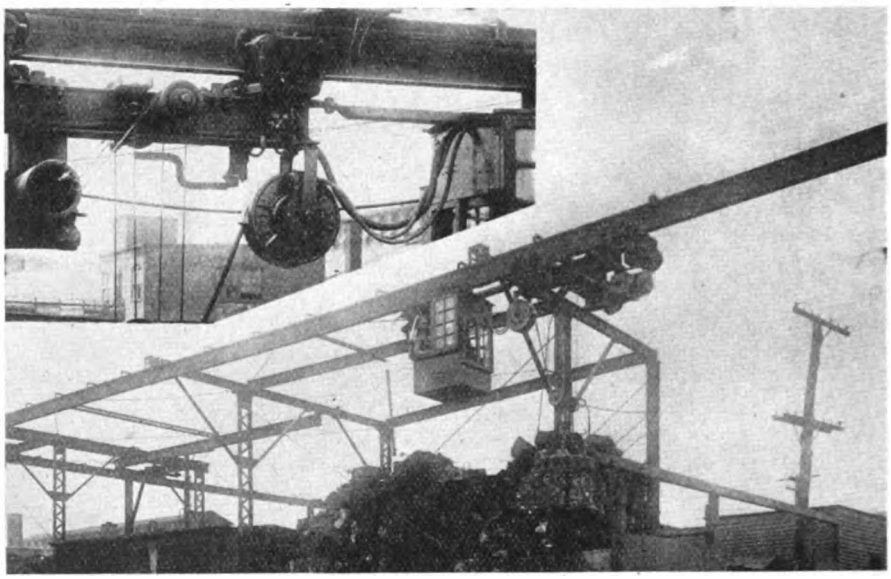
The Benjamin Electric Manufacturing Company of Chicago, Ill., has developed a dust-tight glass cover for use on its 14-in. R. L. M. reflector unit.

A new floodlight projector having a heat-resisting semaphore lens in the front door and a heat-resisting prismatic glass reflector on the inside of the rear door has been placed on the market by the Crouse-Hinds Company, of Syracuse, N. Y. The maker states that this projector is not affected by lamp heat, gases, rain or snow and is intended particularly for use around steel plants and railroads.

The Holophane Glass Company, Inc., of New York, N. Y., has developed a High Mounting Height Unit which it states has an effective candlepower downward of approximately double that of either the deep bowl or shallow bowl type of steel reflectors. The maker reports that this unit is especially adaptable for the illumination of buildings where the lighting units must be hung at considerable heights as above the craneways as shown in a "before and after" illustration accompanying this section.

Tindall & White, Inc., New York, N. Y., report that their Perfection shade has been approved and endorsed by the New York State Industrial Commission as meeting the code requirements in all respects and giving no glare even when used with clear lamps.

Several new types of signal lanterns have been developed by the Nichols-Lintern Co. of Cleveland, Ohio. These lights are intended for use as warning, danger, or signal lights around industrial plant yards and buildings. A feature of the lights is that they have cast-aluminum frames which the manufacturer states will defy rust and acid atmospheres and will not crumple under rough handling; further the lamp bulb is so completely enclosed that it is entirely dustproof and moisture-proof. These lanterns, as shown in the accompanying illustration, are made with cylindrical Fresnal lens or with 1-way or 5-way Corning optical lenses in four different colors as desired. This company has also developed a combination signal lantern and reflector unit using one lamp or two in such a manner that the upper part of the unit is a warning signal while the lower part throws a strong beam of light down on the dangerous area.



Retrieving reels are said to increase the life of magnet cables.

This illustration shows a Mogul type Reelite made by the Appleton Electric Company, Chicago, Ill., installed on a monorail crane in a junk yard. This Reelite automatically pays out and retrieves 45 ft. of No. 8 four-conductor cable as the magnet is hoisted and lowered.

Lamps.—Probably one of the biggest developments in lamps was the announcement by the General Electric Company of a reduction in price of approximately 10 per cent on nitrogen-filled, Mazda lamps ranging in size from 100 to 1,000 watts. The lamps on which the reduction was made comprise the bulk of the lamps used by industrial plants.

A theft-proof lamp has been developed by the Kulp Theft Proof Lamp Company of Chicago, Ill. This incandescent lamp is standard in every respect and resembles other incandescent lamps in appearance, but has the added feature that it cannot be removed from the socket without being destroyed. The base is provided with an outer shell which is sealed to the inner shell. The outer shell is threaded to fit the socket, but the inner shell has no thread. After screwing the lamp into the socket an additional turn breaks the seal between the shells and the lamp then turns freely around in the socket. The only way to remove it is to break the glass and reach the outer shell. This lamp is being made in all sizes, both vacuum and gas-filled, and is said to cost no more than other lamps without the theft-proof feature.

Miscellaneous Lighting Supplies.—A device that will clean and polish the light fixtures directly from the floor has been placed on the market by the Electric Light & Reflector Cleaner Company of Appleton, Wis. The apparatus consists of a set of telescoping tubes, the upper tube controlling three arms that grip the reflector under spring tension and prevent it from turning. Inner tubes control the brush mechanism. A handle at the bottom raises the mechanism into contact with the reflector and lamp, while the lever at the side of the handle holds the brushes against the surface to be cleaned. A crank at the bottom revolves the brush mechanism.

The Thompson Electric Company of Cleveland, Ohio, has changed the name of its safety disconnecting hanger to Thompson Safety Lowering Switch. This name was thought to be more typical of its function. The maker states that this device enables all lamp maintenance work to be done on the ground, thus eliminating all climbing and electrical hazards, and making the work more likely to be done. The new underslung design involves several improvements.

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In this model all of moving parts except the wheel are lowered to the ground with the lighting unit; provision is made for enclosing the line wires entering the upper member of the device and also for dead-ending the chain, as well as for enclosing the chain in conduit.

The American Fixture Company of Milwaukee, Wis., reports that its industrial, adjustable light fixtures are now made for attachment directly to the conduit fitting.

Wiring Devices

A new type of wire connector has been developed by the Ideal Commutator Dresser Company, of Sycamore, Ill. The manufacturer states that this device does away with the use of tape, solder and blow torch and decreases the time required to make wire joints. These connectors come in several sizes to handle all regular stranded and solid wire combinations. To make a joint, the wires are skinned and twisted, leaving about an inch of wire exposed. The connector is then screwed on to the twisted pair of wires. Inside the connector is a copper-covered steel wire coil that bites into the copper wires and which is said to hold them fast, making a perfect mechanical and electrical connection.

A "Ground It" bushing has been developed by the Groundulet Company, Newark, N. J., for use on conduits which are to be grounded or otherwise electrically connected. The bushings are made of malleable iron, galvanized and provided with an ear which is drilled and tapped to receive a stud. The stud is provided with a socket to which the grounding wire may be soldered. A hole is located in the bushing in such a position that when the stud is screwed into place, the stud comes into contact with the threads of the conduit. This not only establishes an intimate electrical contact with the conduit, but it also locks the bushing firmly on the conduit and as the stud thread is mutilated when the stud is screwed home, there is little possibility of its working loose.

A new weatherproof, armored connector for electrical circuits has been developed by The Ohio Electric & Controller Company of Cleveland, Ohio, for use where connections must be made and broken frequently and kept insulated, especially where they are exposed to hard knocks or the weather. Connection and disconnection are affected without tools by a double bayonet type lock as shown in one of the accompanying illustrations.

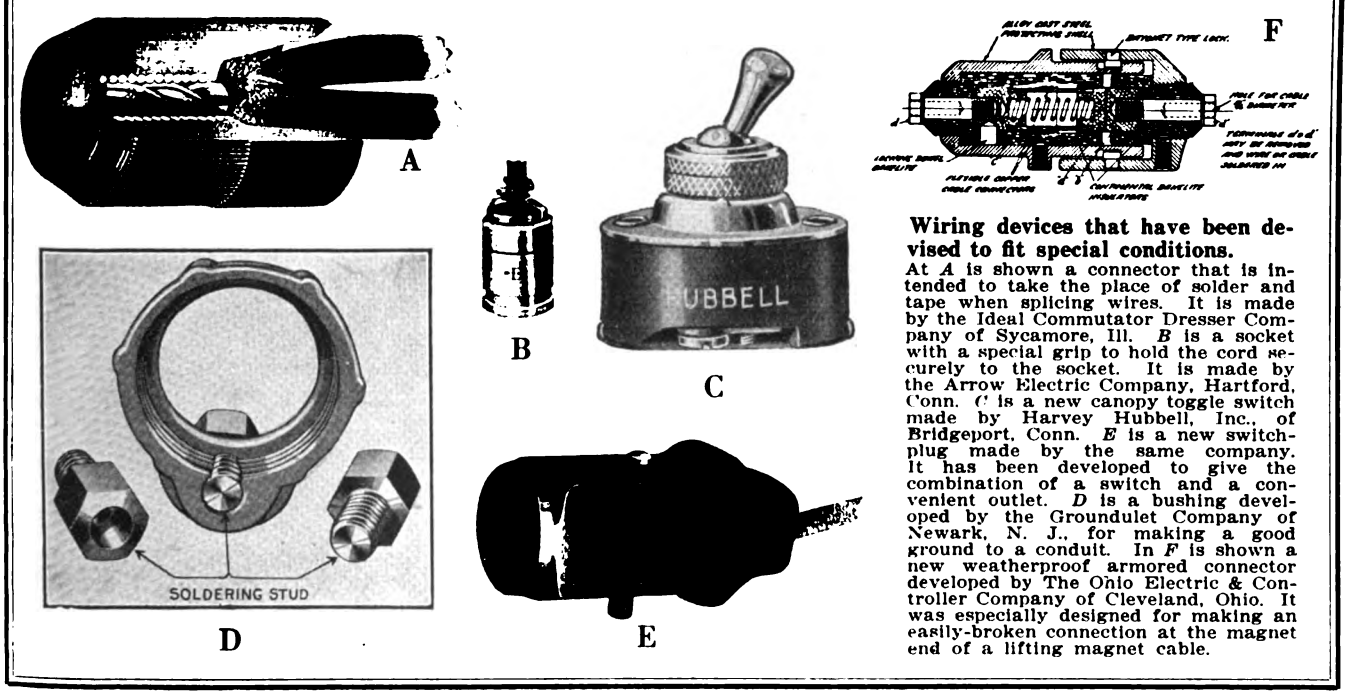
A complete line of pipe fittings which are designed for use with common wrought-iron or steel pipe in the erection of outdoor or indoor electrical switching equipment, has been placed on the market by the Westinghouse Electric & Manufacturing Company. While they are designed primarily for electrical installations, the new fittings are equally applicable for the construction of racks, railings and bench or table frames.

The "Shurlock" is a locking feature that has been developed by Pass & Seymour, Inc., of Syracuse, N. Y. This feature is designed to prevent the unauthorized removal of lamps from their sockets. It also may be used to prevent lamps from loosening in their sockets due to excessive vibration.

Construction and erection costs can be reduced through the use of the Adaptibox line of conduit fittings is the report received from the Adapti Company of Cleveland, Ohio. These conduit fittings instead of being made in one piece, consist of a base having four interchangeable sides. This feature permits any special requirement to be instantly met by the contractor or plant engineer, right on the job if necessary, by reassembling standard units to make up the types needed. Also since the outlet sides can be screwed on to the conduit and afterwards attached to their respective bases, it is in many cases possible to assemble entire sections of the conduit on the floor and then attach them to the bases already in place on the ceiling.

The Arrow Electric Company inform us that their new Arro-Grip feature has been extended to a complete line of sockets and rosettes as well as to the attachment plugs.

A new switch-plug has been developed by Harvey Hubbell, Inc., of Bridgeport, Conn. In many shop and factory installations the ceiling lighting unit closes up the only con-



Wiring devices that have been devised to fit special conditions.
At *A* is shown a connector that is intended to take the place of solder and tape when splicing wires. It is made by the Ideal Commutator Dresser Company of Sycamore, Ill. *B* is a socket with a special grip to hold the cord securely to the socket. It is made by the Arrow Electric Company, Hartford, Conn. *C* is a new canopy toggle switch made by Harvey Hubbell, Inc., of Bridgeport, Conn. *E* is a new switch-plug made by the same company. It has been developed to give the combination of a switch and a convenient outlet. *D* is a bushing developed by the Groundulet Company of Newark, N. J., for making a good ground to a conduit. In *F* is shown a new weatherproof armored connector developed by The Ohio Electric & Controller Company of Cleveland, Ohio. It was especially designed for making an easily-broken connection at the magnet end of a lifting magnet cable.

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venient or available outlet to which a heating appliance, fan, motor-driven appliance, or any other electric device used, can be connected. To meet this unfavorable situation, the Hubbell switch-plug was developed. It combines both an independent switch for the ceiling unit and a T-slot outlet into which an electric device can be plugged. The switch controls the light only; the cutlet is always "alive."

This company has also developed a multiple plug which may be plugged into a single plug outlet thereby converting it into a double outlet.

A new remote control switch rated at 15 amp., 125 volts, has been developed by the Hart Manufacturing Company of Hartford, Conn. The maker informs us that this switch was especially designed for the automatic switch control of small amounts of current and is adapted for the control of small motor-driven sirens and oven units with thermostatic control.

A new conduit box switch, known by the trade name Levolier, has been placed on the market by the McGill Manufacturing Company of Valparaiso, Ind. This switch is rated at 6 amp., 125 volts, or 3 amp., 250 volts, and is intended to do away with the necessity of running extra conduit to the switch, inasmuch as the conduit box switch is installed at the fixture.

A new model of the Autex automatic extension reel is reported by The Cincinnati Specialty Manufacturing Company of Cincinnati, Ohio. The maker states that this new model has an improved side contact, a new clamp which was added to hold the cord secure, and that the reel is now equipped with Belden Tuff Rubber Cord instead of the fabric cord previously used. Two sizes of reels are made: one having a 9-in. disk and carrying 25 ft. of cord and the other having a 13-in. disk and carrying 50 ft. of cord.

The Appleton Electric Company of Chicago, Ill., informs us that many manufacturers are making operation of portable tools more convenient through the use of Reelites for paying out and retrieving the cord running from the power supply outlet to the tool. This company also informs us that its Mogul type Reelite is finding extensive application for paying out and retrieving the power supply cable on magnet handling cranes.

During the past year the Truscon Steel Company of Youngstown, Ohio, has developed a steel pole of copper bearing steel which is said to do away with rusting and the costly galvanizing which has heretofore been required on steel poles to prevent rusting.

How Maintenance Is Handled

(*Continued from page 51*)

This continual watch for mal-adjustments, etc., does much to prevent serious troubles and consequent loss in production machine hours.

A straight-line organization is in effect, with the works engineer in charge. The following men are responsible and report to the works engineer:

Millwright foreman
Chief electrician
Janitor foreman
Watchman
Elevator operators
Safety inspectors
Construction gang foreman during construction periods
Foreman of millwright dept. at Cortland Works.

Aside from these responsibilities as works engineer, the writer is president and manager of the Corona Building and Improvement Company, Inc., a subsidiary of the parent company. This company has purchased land, laid out streets, sewer systems, etc., and erected 83 homes and maintains them and also owns and operates a rooming house consisting of 32 rooms, dining room and kitchen and garage which is furnished to the parent company for the storage and maintenance of its trucks and passenger cars.

Maintenance Tools and Equipment

(*Continued from page 89*)

Electric Company allows welding operators to make a quick change from burned stub to new electrode. The maker points out that the operator need only strike the stub end of the old electrode, causing it to drop out, when the new wire can be inserted instantly without unnecessary effort.

Miscellaneous Supplies.—A voltage tester that does not require the use of lamps has been announced by the Square D Company of Detroit, Mich. The maker informs us that this tester will indicate whether the current is a. c. or d. c. and will also indicate potentials from 125 to 500 volts. It is intended to replace lamps in locating open circuits, blown fuses, and motors running single phase. It may be used in emergencies as a voltmeter.

A new product, known as Imperial Commutator Cement, has been placed on the market by the Martindale Electric Company of Cleveland, Ohio.

Several new insulating varnishes have been developed by The Sterling Varnish Company of Pittsburgh, Pa. Among these is Jetlac, a spirit finishing varnish that the manufacturer states air dries in from 2 to 10 min., depending on the method of application. It is said that this material gives a beautiful, deep glossy black coat that is oil-proof and very resistant to water, acids and alkalis; also it is flexible and heat enduring. The maker also informs us that he has developed a complete and entirely distinctive line of baking insulating varnishes, that are designed especially for application to coils wound with enameled wire. These varnishes range from those which, because of their unusual mechanical strength are especially adapted to the treatment of high-speed motor armatures to those that are characterized by their adhesiveness and extreme resistance to heat. They are oil-resistant but at the same time provide protection against water, acids and alkalis. Their special solvent, having an extremely high flash point, is said to render them as nearly non-inflammable as is at present possible.

W. J. Jeandron states that four new grades of Le Carbone brushes have been recently developed. Grade EGA is reported to be especially adapted for 250-volt rotary converters and motor-generator sets where the speed is not in excess of 4,500 ft. per min. and the current density is about 55 amp. per sq. in. Grade EGSP is said to be adapted to 500-volt rotary converters and motor-generator sets with approximately the same speed and current density as listed above. Grade EGH is designed for automatic rotary converters where the brushes run in a trailing position. Grade CG 3,371 is intended for use on bronze rings on rotary converters where the current density does not exceed 100 amp. per sq. in. and a ring speed of approximately 4,500 ft. per min. The maker informs us that this brush has a low co-efficient of friction and causes little ring wear.

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A new, unique and efficient drill has been developed by the Van Expansion Bolt Manufacturing Company, Chicago, Ill. This drill is intended for use in drilling holes in brick, concrete or stone. It has fluted or grooved sides which permit ample clearance. Inasmuch as the diameter of the drill is the same throughout its entire length, it never becomes undersize. The manufacturer reports that the drill is so tempered that the life of the drill is practically unlimited, as it can be re-sharpened and used as long as enough stock is left to hold in the hand or insert in the chuck.

The Westinghouse Electric & Manufacturing Company has informed us that a means has been recently perfected for forming micarta rod with the laminations concentric to the axis and with the center as solid as the exterior portion. Such a rod can be machined without the difficulty of splitting out, as is the case with the soft-core rod.

Mechanical Power Service Equipment

(*Continued from page 64*)

power tank, known as M116 and M109 respectively, for use with the "Dot" high pressure lubricating system. The electrically driven outfit comprises a cylinder made from heavy, seamless brass tubing in which the lubricant can be put under any pressure up to 2,500 lb. per sq. in. by means of a 3-piston booster pump driven by a small electric motor. The pressure can be adjusted to any desired value up to 2,500 lb., by means of check nuts back of the piston springs. This outfit is mounted on wheels for easy transportation around the plant.

The hand-power tank consists of a cylinder made of seamless brass tubing, in which any pressure up to 3,000 lb. per sq. in. may be developed by bearing down on the handle of the booster pump. There is a ball valve at the base of the pump which opens with each stroke of the plunger and immediately closes at the end of the stroke, thus maintaining pressure in hose and gun.

Star Expansion Bolt Company, New York, N. Y., has placed on the market a new device known as the "Dryvin Anchor," for making attachments to masonry or brickwork. This consists of a metal shield and lead sleeve which are inserted in a hole drilled in the brickwork. The shield is then expanded by driving a nail into it. This shield is made in several sizes ranging from 3/16 in. to ½ in. diameter and it is claimed will develop ultimate holding loads from 400 to 4,000 lb., in good masonry. Other claims are that the expansion takes place below the surface of the masonry and that the pressure is distributed over a large area.

A new line of gooseneck welding torches has been developed by The Bastian-Blessing Co., Chicago, Ill. It is claimed that these torches are an improvement over other torches of similar design in that the gases do not mix in or near the operator's hand and that they contain all of the features patented by this company for the elimination of backfire and production of maximum efficiency of gas mixture.

Weiss Engineering Corporation, Newark, N. J., is introducing the Weiss universal joint, of which it is claimed that the distinguishing feature is that it transmits uniform angular motion when driven at a uniform rate. Each end of the joint is formed with four jaws projecting in the direction of the shaft, which interlock with the corresponding jaws of the other member. Rolling contact is maintained between the two principal members by means of a series of balls, through which the driving torque is transmitted. These balls are held in specially-formed raceways so that each ball is sunk approximately half its diameter in the face of one jaw and an equal depth in the opposing face of the next jaw.

The American Blower Company, Detroit, Mich., is now producing a Venturafin Heating Unit having about three times the heating capacity of the original Venturafin Unit Heater which was placed on the market last year.

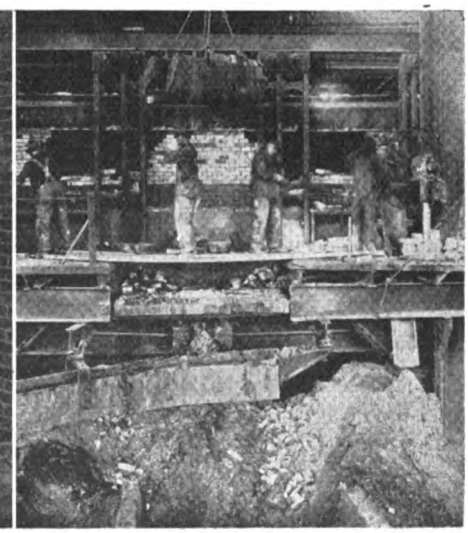
It is claimed that these heaters are unique in that they make use of a peculiar form of tubular construction. The steam tubes are of thin copper, offering little resistance to the passage of heat. Still higher transmission efficiency is given by winding the tubes with a helical brass "fin," which gives them about three times their ordinary heat-radiating surface. These tubes are assembled into units and forced circulation of air through the tubes is provided by a motor-driven fan.

The small unit weighs 320 lb. and has a capacity ranging from 125,000 to 162,500 B.t.u. per hour, depending on the initial and final temperatures. The larger unit delivers from 500,000 to 650,000 B.t.u. per hour and weighs 1,060 lbs.

At the left are shown two of the seven Venturafin unit heaters, made by American Blower Co., installed in a large planing mill. Center, portable, single-inlet, H.S. fan for induced draft in brick kilns. Right, a No. 7 Man Cooling Fan on duty in a Southern steel mill.







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Material Handling Devices That Pay

(*Continued from page 70*)

existing equipment or to incorporate new developments. Four of these new developments have been illustrated on page 70. One of these has been added to the line of the Roeper Crane & Hoist Co., Inc., Reading, Pa., which was formerly known as the Reading Crane & Hoist Co. Some new developments have been added to the Lo-Hed electric hoist manufactured by the American Engineering Company, Philadelphia, Pa. This hoist is so constructed that the hook can be drawn up close to the rail, thus making the hoist available in places where the headroom is very low. Still another electric hoist, known as type CM was developed by the Chisholm-Moore Manufacturing Co., Cleveland, Ohio. This hoist contains a standard enclosed crane motor; a controller especially built for hoist service; two reductions in spur gear; a Weston load brake; a mechanically operated motor brake and other features.

The Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., has added the LiftAbout, Jr., which is built for handling 500-lb. loads, to its line. This is very similar to the LiftAbout, except that it is of less capacity, and is built for handling light loads quickly, such as rolls of cloth in textile mills, baskets of cans in canning factories, handling materials for pickling, handling machine products for cleaning, dipping or painting operations, for serving lathes and other machines.

The Sullivan Machinery Co., Chicago, Ill., has increased its line of air and steam hoists, by adding a 1-ton capacity electric hoist to its line. In addition, the Ingersoll-Rand Co., New York City, is now offering a new line of air motor hoists made in five different sizes with capacities ranging from 500 to 10,000 pounds.

Two new types of cupola chargers were developed during the past year. The type developed by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., is constructed in either cage or floor operated electric hoist types and carries the load on an extension beyond the trolley with the cage acting as a balance to the load. The charge is handled in drop-bottom buckets, with magnets or in grab buckets.

A cupola charging hoist for somewhat similar general operation was also brought out by The P. H. & F. M. Root Co., Connersville, Ind. In one installation of this cupola charger a crew of three men did the work formerly requiring six men. Here the cupola was charged with 150 tons per day or 19 tons per hour. The complete cycle of operation of each charge from the scales to the cupola and return required six minutes for each 10,000 pounds of charge so that the hoist was operating about 50 per cent of the time.

Several interesting features are incorporated in the 10-ton crawling crane brought out by the Industrial Works, Bay City, Mich., for general yard use for handling coal and miscellaneous purposes. An improved model of the 20-ton locomotive crane has been brought out by The Brown Hoisting Machinery Co., Cleveland, Ohio.

Magnets are being applied as a part of practically all hoisting equipment handling iron or steel. Many unusual applications have been reported. In one case an Ohio magnet is used to dip rolls of wire in an acid bath. The magnet is protected by frequent coatings of asphaltum paint.

Three conveyor developments have been reported by the Stephens-Adamson Mfg. Co., Aurora, Ill. One of these is a portable, high-speed, belt-conveyor, box-car loader for throwing material into the farthest corner of the box car. This may also be used for unloading cars. The other developments consist in adopting high pressure lubrication to the ball bearing unit carriers for belt conveyors and also for the conveyor chain. These two parts of the equipment have been extremely difficult to lubricate and are continually operated under extremes.

Users of conveyors are paying considerably more attention to specifying the use of ball bearings and better methods of lubrication for both gravity conveyors and also for the rolls supporting belts in other conveyors.

Conveyors are occupying an important place in material handling, especially where an almost uniform and continuous supply of material is to be delivered over a fixed path. Belts and bucket conveyors also have well demonstrated their value in handling loose material. For example, one belt conveyor system, containing almost 4½ miles of 48-in. conveyor belt, carries coal from a mine to the loading station at the continuous rate of 1,200 tons per hr. This has taken the place of locomotives, cars, track and the difficulty of unequal distribution of the deliveries of coal as well as a large force of men. Belts are also used for carrying supplies that must be mixed in certain proportions such as the constituents of brass or rubber, to weighing scales and from there to the process. Another interesting conveyor installation reported by Weller Mfg. Co., Chicago, Ill., is a special conveyor used to store and reclaim beets at a Western beet sugar factory.

A number of interesting applications of roller and slat or apron conveyors have also been reported from practically all industries. Many concerns are finding that progressive assembly can be adapted to many industries and processes, cheese making, for example, and is not limited to straight mechanical assembly operations as in the automobile industry. Practically all of the new sawmills, large planing mills and shook plants are handling much of the material by conveyor systems. Many plants are finding conveyors much more economical than the use of large gangs of men even though labor was not so difficult to obtain. The economy feature, however, well repays the investment.

Other miscellaneous new equipments reported are: A new type of trailer for tractor service, by Mercury Mfg. Co., Chicago, Ill.; additional pressed-steel boxes and platforms for hand- and power-lift trucks, by The Youngstown Pressed Steel Co., Warren, Ohio; improved models of hand and electric "Transveyors," by Cowan Truck Co., Holyoke, Mass.; and a new Super Multiple-Lift hand-lift truck by Stuebing Truck Co., Cincinnati, Ohio., by which one man can handle 5,000-lb. loads in four short lifts.

With the increasing knowledge of the value and economy which may result from the use of material handling equipment, the coming year will no doubt show much greater utilization of this equipment.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for their assistance in furnishing information on material-handling equipment: American Engr. Co., Philadelphia, Pa.; The Baker R. & L. Co., Cleveland, Ohio; Barrett-Cravens Co., Chicago, Ill.; Bond Foundry & Machine Co., Manheim, Lancaster Co., Pa.; The Brown Hoisting Machinery Co., Cleveland, Ohio; Chisholm-Moore Mfg Co., Cleveland, Ohio.; Cleveland Crane & Engr. Co., Wickliffe, Ohio; The Crescent Truck Co., Lebanon, Pa.; Cowan Truck Co., Holyoke, Mass.; The Dow Co., Louisville, Ky.; Econ-

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omy Engr. Co., Chicago, Ill.; The Elwell-Parker Elec. Co., Cleveland, Ohio; Faultless Caster Co., Evansville, Ind.; Harnischfeger Corp., Milwaukee, Wis.; The Jeffrey Mfg. Co., Columbus, Ohio; Industrial Works, Bay City, Mich.; Ingersoll-Rand Co., New York City; The Lamson Co., Syracuse, N. Y.; Lewis-Shepard Co., Boston, Mass.; Link-Belt Co., Chicago, Ill.; Mercury Mfg. Co., Chicago, Ill.; New Jersey Foundry & Machine Co., New York City; Ohio Elect. & Controller Mfg. Co., Cleveland, Ohio; P. H. & F. M. Root Co., Connersville, Ind.; Roeper Crane & Hoist Co., Reading, Pa.; Service Caster & Truck Co., Albion, Mich.; Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.; Standard Conveyor Co., North St. Paul, Minn.; Stephens-Adamson Co., Aurora, Ill.; Stuebing Truck Co., Cincinanti, Ohio; B. F. Sturtevant, Boston, Mass.; Sullivan Machinery Co., Chicago, Ill.; Weller Mfg. Co., Chicago, Ill.; The Yale & Towne Mfg. Co., Stamford, Conn.; The Youngstown Pressed Steel Co., Warren, Ohio.

Mechanical and Electrical Changes

(*Continued from page 54*)

of our motors from open-type sleeve bearings, to inclosed-type roller bearings in some of our dusty and dirty departments where there is a great deal of flying dust, sand and chips.

We expect to make several changes in the machines in the machine shop, in order to avoid double handling, and to increase the number of pieces machined per day.

Several changes in the lighting conditions in several different departments have been started in order to get better light for the employees, and to have it where it is needed and can be used to the best advantage.

It is expected that several changes will be made in belt-driven machines, changing them to chain drive and thereby increasing the power and doing away with belts and shafting.

We have recently put into service two large portable electric drills with capacities up to 1½ in., in order that heavy repairs can be made on the job without taking the work to the shop. One drill is a three-phase, 220-volt machine and the other is a universal 220-volt, a.c. and d.c. machine.

* * * *

Keene Richards, Industrial Engineer, Grennan Bakeries, Inc., Detroit, Mich.—For our lighting installation we have standardized white enameled steel reflectors and the grouping of the lighting switches on a panelboard in each department. This panelboard is so located that the fuses are locked up and accessible only to the electrician, while the switches are exposed and are operated by the department foremen.

Many departments have not been changed over in this way, but we contemplate making these changes within the next year.

Lighting circuits have been so grouped that the parts of the room which get dark first are on a separate circuit.

We are gradually changing over all switches on production machines which are started and stopped frequently, to remote control even though the motor may be only of one or two horse power. We find that this change-over costs us about $65 but soon pays for itself in absence of fuse trouble, etc.

As our machinery is used in the manufacture of food products and requires daily washing, we found it practically impossible to mount the ordinary type of switch on or near the machine and not get into trouble. We now mount a water-tight, control button directly on the machine, with the remote control switch back on the wall or column.

We have for some time used direct-connected motor drive on all motor equipment. This policy we are continuing. There are a few cases where group drive might be more efficient, but in a plant handling food products overhead shafting and belting cannot be tolerated.

Elevator maintenance is a difficult and expensive item. In new plants and additions we are installing conveyors and not elevators, as we find that a properly-designed conveyor system is cheaper, easy to maintain, more efficient and more flexible. We have even gone so far as to install a conveyor for receiving material in order to relieve the load on elevators.

I would like to place particular emphasis on the use of remote control switches even for very small motors. The saving on fuses and maintenance on an installation costing $65 or $75, as against the ordinary protected switch costing $5 or $6 will very easily pay for itself in two years exclusive of the amount of time saved by keeping the machine in service.

* * * *

W. T. Price, Works Manager, Westcott Valve Company, Inc., Seneca Falls, N. Y.—We have not made any changes during the past year, as we did not think any were necessary, for the reason that we have not had any trouble.

All of our lines were installed with considerable forethought and have stood the test. All lines from which motors are drawing power were installed 50 per cent heavier than was necessary. This has proven good judgment as we have been able to add motors to the line without lowering the efficiency of said line.

All motors are kept clean and well oiled, and are looked after twice a week. All motors are installed with knife switch fuse box and protected by an overload device, with an automatic starter ahead of these. We have found that this was good judgment as it practically eliminated all motor troubles.

We do not contemplate any changes in our present equipment, other than those occasioned by moving our plant to another city.

If we had the necessary capital and could do so, we would have every machine in the plant a direct-connected, electrically operated unit, excepting the real light machines.

* * * *

L. A. Wynd, Chief Electrician, Keystone Steel and Wire Company, Peoria, Ill.—The Keystone Steel & Wire Company has made one important step in the application of power during the past year. Briefly, this step consists of using an 80-hp., mill-type motor as a booster on one of our main drives.

Last July, mechanical changes in the rod mill increased the tonnage to the point where additional power was necessary to drive the mill to its limits consistently.

A spare General Electric Co. MD 107 series motor was changed to compound by a replacement of the field coils and belted to the 1,300-hp. finishing mill main drive motor with the idea of slightly boosting the finishing mill power. As this motor is belted to the main motor it requires no starting resistance and is placed in operation automatically by first closing the shunt field circuit and then closing the armature circuit through a magnetic contactor interlocked with the main motor control at the top-speed position. This experiment is working so well that plans are now under way to purchase two larger motors and belt them to the finishing and roughing mills to assist the main motors.

The new booster motor on the finishing mill will be a 2,300-volt, three-phase, 60-cycle, wound-rotor motor of 250 hp., belted to the mill and arranged to be cut in on the line through an oil-immersed magnetic switch as soon as the Schebius-regulator-controlled 1,300-hp. main motor reaches its highest speed above synchronism. The finishing mill part of the rod mill is worked at top speed about 98 per cent of the time and a more expensive control for the booster is not justified. The installation of this motor presents a comparatively simple problem.

A 300-hp., 230-volt, d.c., shunt interpole motor will be used to boost the power of the roughing mill and must work with the 2,300-hp. Scherbius-regulated main motor. This booster motor will be cut into service at point 15 above synchronism and will work through the rest of the range to point 24 above synchronism, which is top speed for the main motor. Its armature current will be held close to 100 per cent at all points through automatic field regulation. No starting resistance will be necessary. This application, while more complicated than the one on the finishing mill, is perfectly practical.

* * * *

A large paper mill reports that the only change of importance made during the past year was in changing the paper machine drive from steam engine to electric motor. Originally this machine, which was of the electric drive type, was supplied from a d.c. generator driven by a steam turbine. Trouble developed in the turbine, causing fluctuations which were annoying. Recently the turbine was taken out and a 350-kva. synchronous motor connected directly to the generator. As the average load on this motor is only 180 hp. the remainder of the available capacity is utilized for power factor correction.

Previously, a 400-kva. synchronous motor floating on the line was used for power factor correction only. After the installation of the 350-kva. motor it was found possible, by over-excitation of the latter, to dispense entirely with the larger motor. The costs of the steam and electric generator drives were found to be practically the same, while the paper machine operates much more satisfactorily with the constant-speed generator drive.

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Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Light and Work—By M. Luckiesh, Director, Lighting Research Laboratory, National Lamp Works of General Electric Company. Published by D. Van Nostrand Company, 8 Warren street, New York, N. Y., 290 pages, 70 illustrations, price $4.00.

This book presents a very practical discussion of the relation of quality and quantity of light to effective vision and efficient work. It presents material of use not only to the designer but also to all users of light and particularly to men connected with the application of light to industrial plants. Artificial light has become a serious competitor of daylight on a cost basis and is far superior from the viewpoint of control. The author compares artificial light with natural lighting on the basis of quality, quantity, and cost. A discussion is given on the best range of illumination intensity and also the best quality of light for effective work as influenced by efficient vision. Some rather surprising conclusions are reached pertaining to the economic value of adequate and proper lighting and to the amount of artificial light that we can afford to use at the present time. Chapters of particular interest to industrial men are those pertaining to light and production, the value of proper maintenance of lighting systems, the lighting value of paint, visibility and safety, and the most effective and economical intensity of illumination.

* * * *

Applied Electricity for Practical Men—By Arthur J. Rowland. Published by the McGraw-Hill Book Company. Second edition, 431 pages, price $2.50.

The first edition of this book was brought out in 1916. The revision includes many changes and new material to bring developments in the application of electricity up to date. For the most part the book deals with fundamental principles of interest to electricians who are engaged in construction and operating work on lighting and power systems. It will also be found a useful text in vocational and trade schools.

* * * *

Principles of Electroplating and Electroforming—By William Blum, chemist, U. S. Bureau of Standards, and George B. Hogaboom, electroplating adviser, U. S. Bureau of Standards. Published by McGraw-Hill Book Co., 370 Seventh Avenue, New York, N. Y. First edition, 356 pages, illustrated, price $4.

The authors have for several years been engaged in the study of electroplating and electroforming processes and this book has been prepared to assist those in the industry to apply the results that have been, or may be, secured in various research institutions.

In keeping with the object, considerable space is devoted to an easily-readable exposition of the chemical laws and principles of electrochemistry concerned in the electrodeposition of metals from aqueous solutions. In the succeeding chapters such subjects as, factors governing character of deposits, preparation for electroplating, preparation for electroforming, electrical equipment, tanks and their equipment, and the deposition of copper, nickel, zinc, lead, tin and other metals are discussed in detail. An appendix contains a number of very useful tables.

In many respects this book is a noteworthy addition to the literature on this branch of the electrochemical processes and is deserving of a place in the library of everyone who is interested in the subject from any standpoint.

* * * *

Industrial Electricity—Direct Current Machines—By William H. Timbie, Professor, Electrical Engineering and Industrial Practice, Massachusetts Institute of Technology. Published by John Wiley & Son, Inc., New York City, 721 pages, 469 illustrations. Price $3.50.

This book was written to meet the demand from technical schools and electrical workers for a text covering the important principles of electrical science as applied to modern industry. The purpose of the book is to explain how direct-current electricity is generated, transmitted and used, and to afford an adequate foundation for further study of the application of alternating-current electricity to modern practices. The problems are based on the principles of present day industrial practices. Over a thousand typical examples and practical problems, based on engineering data, have been added to emphasize the principles and illustrate their uses. Explanations are made in a simple and practical way in a language which a student can easily understand and without the use of mathematics beyond simple algebra.

* * * *

Magnets—By Charles R. Underhill. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City, 449 pages, price $4.00.

This is a practical treatise on electromagnetic devices, their circuits, and the specific forms and characteristics of electromagnets and permanent magnets. The author is a well-known consulting engineer and authority on this subject who has had a wide experience in the design of electromagnetic devices. While the book contains certain technical information, the discussions are intensely practical and refer to the applications of magnets in all equipment that uses them. The information is not only of value to the designer but to the operator who must inspect and repair magnets. This book will be found to be a very complete and useful reference. The subjects treated are as follows: forms of electromagnets; mechanical forces of electromagnets; time and polarity characteristics; portative electromagnets; switching, control, and protective apparatus; relays; miscellaneous electromagnetic devices; solenoids; constant-current solenoids with plungers; test characteristics of solenoids with plungers; general characteristics of solenoids with plungers; direct-current electromagnets; electric circuits and their phenomena; constant-impressed, direct-voltage, current-time characteristics; magnetic circuits and their phenomena; series and shunt magnetic circuits; magnetic materials; air gaps and magnetic leakage; alternating-current phenomena; series and parallel alternating-current circuits; alternating-current solenoids; alternating current-electromagnets and mechanisms; electromagnets in general; and permanent magnets.

* * * *

Handbook for Electrical Engineers—By Harold Pender, editor-in-chief. Published by John Wiley & Sons, New York City. Revised edition, 2,196 pages, price $6.00.

This handbook was originally brought out in 1914. The necesary revisions to bring it up to date have been made throughout all sections. In addition, new material has been added on the following subjects: frequency changers, electric ignition; phase converters and balancers; electric propulsion of ships; starting and lighting systems for automobiles; and electric welding. Of the main articles 17 have been entirely rewritten and considerable change has been made in 24 other articles. The general plan of the book remains the same, with an encyclopedic arrangement of subjects, and a topical list of articles with page numbers supplemented by an elaborate index.

In the revision of this book Harold Pender, the editor-in-chief, has been assisted by Wm. A. Del Mar, who is a well-known authority on electrical distribution. Forty-two other associate editors who are authorities along particular lines of electrical work have helped on the revising and rewriting of articles in this edition. This book is, therefore, a carefully-compiled, up-to-date handbook covering all phases of electrical work.

* * * *

Conduit Wiring—By Terrell Croft, consulting engineer. Published by McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y., 441 pages, 700 illustrations, price $3.00.

The author deals exclusively with the conduit method of interior wiring, as this method has become the most important of all now in use. The book is written primarily for the man who installs or who directs the installation of the wiring; however, it is equally useful to the engineer, architect or superintendent who plans the installation.

This book explains how to install conduit wiring for all types of buildings, and for all types of work. It covers the conduit wiring job from start to finish, explaining each procedure, step by step, describing tools and materials and pointing out exactly what to do and how to do it.

Specifically, the subjects treated include conduit wiring materials and supplies, method of laying out a conduit job, conduit manipulation and tools, installing concealed and exposed conduit, testing out, splicing and taping conductors, methods of grounding, and the application of conduit wiring in damp and otherwise hazardous places.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

J. E. Rhodes and Sons, 35 North Sixth Street, Philadelphia, Pa.—A 65-page, pocket-size, "Belt User's Book," contains a number of useful rules, suggestions and information on the selection, installation and care of leather belts.

Foamite - Childs Corporation, Utica, N. Y.—A booklet entitled, "Correct Protection Against Fire," is a popular treatise on fire protection for all sorts of risks, and is written in non-technical terms so that the suitability of any type of fire extinguisher for any particular risk may be determined by the layman. One feature of particular interest is a large chart showing the effect of each of the various types of fire extinguishers upon different types of fires.

Boston Woven Hose and Rubber Company, Cambridge, Mass.—A 72-page booklet entitled, "Standards of Practice for Rubber Belting," is written in plain, easily-understandable language and discusses rubber-covered and friction-surfaced belting, the construction and characteristics of these beltings, their application and care, and rules for belting practice. In addition it contains charts and tables for making belting calculations. This is a book which will be of much value to those who use fabric-base belting.

The Van Dorn Iron Works Company, Cleveland, Ohio—Catalog 1004 on, "Convertible Steel Shelving," takes up the capacity and principles of construction and by means of illustrations describes a large number of applications of Van Dorn steel shelving.

General Electric Company, Schenectady, N. Y.—Bulletin Y-2057 entitled, "The Most Efficient Gears for Any Shop," illustrates eight Fabroil gear installations and describes how they solved difficult transmission problems.

Lyon Metallic Manufacturing Company, Aurora, Ill.—Bulletin 105-A entitled, "Lyon Steel Tool Room Equipment," shows by illustrations and diagrams typical shelving, racks and enclosures for toolroom purpose.

Electric Tester Manufacturing and Sales Corporation, 74 East Sixth Street, Portland, Ore.—A folder describes the Universal fuse and circuit tester which may be used on either alternating- or direct-current circuits carrying from 110 to 600 volts. This device eliminates the use of the ordinary test lamp.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis.—Bulletin 4048 describes the Allis-Chalmers-Timken roller shaft bearing, which is made in a housing interchangeable with most of the Allis-Chalmers adjustable collar-oiling shaft bearings, as well as with a number of other makes. This bearing is built in standard sizes for 1 11/16-in. to 4 15/16-in. shafts.

Palmer-Bee Company, 2778-2804 East Grand Boulevard, Detroit, Mich.—Bulletin B-45 entitled, "Speed Reducers," gives a general description, with numerous photographs and drawings, of the construction, operation and the points of superiority claimed for the Palmer-Bee mill-type, spur gear speed reducers which are made in capacities ranging from ¼ to 500 hp., and in ratios from 1.48 to 1, up to 4,000 to 1. This bulletin also contains instructions for ordering and how to select a speed reducer from a number of tables given. Worm gear and right-angle drive speed reducers are also described, as well as high-speed and mill-type Palmer-Bee flexible couplings.

The Berger Manufacturing Company, Canton, Ohio—Catalog 20-B covers the line of Berloy steel bins and shelving, indicates their method of construction and erection and also shows a large number of installations.

The Cleveland Twist Drill Company, Cleveland, Ohio—A 32-page booklet entitled, "Tools for Tuning Up," lists some of the drills, reamers and screw extractors which are most commonly used in repair shops. A folder entitled, "The Best Way Out," describes the Ezy-Out screw extractor in sets for removing broken cap or setscrews or bolts.

Audubon Wire Cloth Company, Inc., Audubon, N. J.—A folder entitled, "A Partition Between," shows some of the various uses of wire mesh for partitions, windows and machine guards. Detailed illustrations show the construction of the joints and of the floor flanges for mounting.

Century Electric Company, St. Louis, Mo.—A folder entitled, "How Century Polyphase Motors Are Built," shows by illustrations the construction of the various important parts.

The Hisey-Wolf Company, Cincinnati, Ohio—Bulletin 3018-S describes the Hisey electric slate and marble drill with a universal, ball-bearing motor which operates the drill at 110 r.p.m. and has sufficient power for drilling holes up to ½ in. diameter in slate and marble. This drill is also adapted for some glass drilling operations.

David Lupton Son's Company, Allegheny Avenue and Agate Streets, Philadelphia, Pa.—Catalog B on Lupton steel factory equipment covers the line of steel shelving with bolted adjustment, steel bins and racks, utility cabinets, bench legs and drawers, steel cabinets, stands and boxes, tool cabinets and stands, tote boxes, foremen's desks and waste bins.

Crouse-Hinds Company, Syracuse, N. Y.—Folder 15 and Bulletin 2058 describe the "Wedgtite" pipe hanger for supporting pipe or conduits from I-beams.

The Bartlett-Hayward Company, Scott and McHenry Streets, Baltimore, Md.—Booklet entitled, "Fast's Flexible Couplings," shows by drawings the construction and by sectional cutaway illustrations the method of lubrication of the Fast coupling which is an all-metal coupling consisting of two generated spur gears, one at each end of the shaft, which are continuously and completely meshed with the generated internal gears of a floating sleeve. Considerable space is given to the principle of lubrication, how to order, how to install and factors to consider in various types of drives. This booklet also devotes space to special couplings, such as telescopic couplings, cut-out couplings, couplings for excessive misalignment and those for large turbo-alternators.

The Mills Company, 5320 St. Clair Avenue, Cleveland, Ohio—A series of folders describe the construction and installation of partitions for factories and offices, for shelving and for standard toilet enclosures.

Monitor Controller Company, Baltimore, Md.—Bulletin 67 describes the Monitor edge-wound resistor, which is designed for heavy-duty service. This resistor is claimed to possess a number of advantages compared with other grids, which are fully explained and discussed. A table gives ratings and approximate dimensions.

Chicago Fuse Manufacturing Company, Chicago, Ill.—An 86-page catalog shows illustrations of Union renewable and non-renewable fuses, Gem enclosed fuses and mica top block fuses, Union links, fuse wire and strip, Union cutout boxes, and a variety of other fittings. This catalog also gives sizes, prices and other information for users.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—A circular entitled "Two Feet of Electrical Heat" illustrates and describes several rather unusual installations of electric strip heaters.

Belden Manufacturing Company, 2300 South Western Avenue, Chicago, Ill.—Recent catalogs and price lists have been issued on various Belden wire, cord and other specialties.

The Sanymetal Products Company, 980 East Sixty-fourth Street, Cleveland, Ohio—Catalog 4 illustrates the construction and installation of standard metal partitions for factory, offices and toilets.

Gits Brothers Manufacturing Company, 1940 South Kilbourn Avenue, Chicago, Ill.—A catalog describes the Gits oil hole covers, oil cups and wick oilers, for oiling industrial equipment.

Diehl Manufacturing Company, Elizabeth, N. J.—Bulletin 1650 covers the Diehl line of a.c. and d.c. motor-driven exhaust fans. These fans are built with totally-enclosed motors.

Gilby Wire Company, Newark, N. J.—A 20-page catalog lists, describes and gives the capacity, sizes and other information as well as price on the line of resistance and other alloy wires manufactured by this company.

Associated Manufacturers of Electrical Supplies, 30 East Forty-second Street, New York City—This organization has recently issued a new handbook which contains: Part One—list of officers, committees and representatives on outside organizations; Part Two—

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the list of member companies with their executive and associate representatives; Part Three—the first published standards of the Association.

International Chemical Company, Philadelphia, Pa.—A series of folders describe the various cleaning compounds manufactured by this company. For example, compound 2B is used in repair shops and other similar places for cleaning parts that have heavy coatings of grease, muck, paint and caked-on dirt; compound No. 22 is used to prevent rusting; cleaner No. 5 is used for cleaning floors. Other compounds are used for cleaning before plating or japanning, for removing oil after machining and for many other similar cleaning purposes.

Tindall and White, Inc., 329 East Twenty-second Street, New York City—A special folder describes the Perfection reflector which is designed for the purpose of diffusing part of the light and directing part on the working surface. This is especially intended for individual lighting or for localized general lighting.

Green Equipment Corporation, Monadnock Block, Chicago, Ill.—A catalog describing Acme commutator smoothing stones gives a thorough discussion of the different types and grades of stones and gives suggestions as to their use. Other catalogs describe the Aurand commutator slotter which is a portable, hand-operated, power-driven tool for undercutting mica without removing the armature and, in most cases, without even removing the protecting shields or brackets.

H. Kleinhans Company, Pittsburgh, Pa.—Folders describe the Mann arc welder which is made in both motor-generator sets and also for gasoline engine drive. One of the features claimed for this generator is that it maintains a fixed current value. By the use of a small field rheostat in the shunt field circuit, the current value may be changed as desired in a large range of steps from 60 to 200 amp. Another bulletin entitled "Precision Welding" describes the use of this equipment in welding machinery such as crankshafts, which must be united with a specific tolerance of misalignment.

The Texas Company, 17 Battery Place, New York City—The December, 1924, issue of "Lubrication," which is a technical publication distributed by this company and devoted to the selection and use of lubricants, takes up the 2-cycle oil engine—its lubrication and operation.

Columbian Rope Company, Auburn, N. Y.—A 54-page book entitled, "Columbian transmission rope is made, discusses rope drive systems, some advantages of rope drives, grooves and sheaves, the proper rope, how Columbian transmission rope is made, splicing Columbian transmission rope (illustrated with 13 photographs and considerable explanatory text) and other useful information.

The Pyle-National Company, 1334-1358 North Kostner Ave., Chicago, Ill.—Various catalogs describe the line of Pyle-National electric headlights, steam turbo-generators for headlights, Pyle-O-Lytes for floodlighting and "Nonglare" glass reflectors.

The American Injector Company, Detroit, Mich.—"The Engineer's Red Book," is not only a catalog on American injectors and oilers but also contains a large number of pages of interesting data as well as questions and answers for the engineer.

The Hill Clutch Machine and Foundry Company, Cleveland, Ohio.—Bulletin T-220 describes the totally-enclosed industrial-type, spur-gear speed transformer with an oil splash system of lubrication. Customary ratios are from 5 to 1 to 125 to 1 for any size of reducer.

Rollway Bearing Company, Inc., Syracuse, N. Y.—A folder describes the application of Rollway bearings for general-purpose electric motors. This bearing consists of short, heavy rollers.

McCord Radiator and Manufacturing Company, Detroit, Mich.—A booklet entitled, "Economy of Better Lubrication," illustrates and describes with numerous sectional diagrams the advantages, economies and operation of McCord force-feed lubricators.

W. R. Ostrander and Company, 371 Broadway, New York City—A 32-page catalog describes the various types of electrical apparatus, such as annunciators, tell-tale floats, bells and buzzers, relays, push buttons, door openers, sockets and other devices. Other catalogs describe fire alarm systems and other alarm and signalling apparatus.

Chase Metal Works, Waterbury, Conn.—A 38-page booklet entitled, "How to Order Brass," points out what properties in brass are desirable for certain typical uses and tells how to order such material so that the manufacturer will understand exactly what is wanted. This booklet also takes up the different physical and mechanical properties of brass and shows the effect of various alloys and of the different methods of manufacturing. The different tests and what they mean are also explained. A table gives the different common types of brasses and other alloys and their typical uses.

General Electric Company, Schenectady, N. Y.—Bulletin 48,721 entitled, "Direct Heat Electric Furnaces in General Electric Factories," shows the use of a large number of furnaces in various operations such as annealing of castings and wire, calorizing, sherardizing and other processes requiring electric furnaces, in different plants of that company.

Harry M. Perry, 2816 North Main Street, Los Angeles, Calif.—A circular describes the slack belt idler which is fitted with a special attachment so that it may be mounted on any motor. This consists of a counterweighted pulley and a special attachment for the motor.

Standard Pressed Steel Company, Jenkinstown, Pa.—This folder describes the Gast loose pulley bushing which is a special oiling device that comes into play only when the loose pulley is in operation.

Tide Water Oil Sales Corporation, 11 Broadway, N. Y.—This 60-page book discusses the principles of lubrication, as applied to prime movers, auxiliary equipment and machinery in the power field. The discussion includes the lubrication of transmission elements, motors and various other kinds of equipment, with diagrams and charts to make clear the application.

Miller Rubber Company of New York, Akron, Ohio—This folder describes the special composition Miller mallet (not made of rubber) which is of laminated construction moulded in one piece. The striking qualities are similar to wooden mallets and will not damage, batter up nor bruise.

General Electric Company, Schenectady, N. Y.—Circular 67495. describes the Type FH oil circuit breaker for controlling high capacity from 7,500 to 35,000 volts, 500 to 4,000 amp.

The Standard Electric Tool Company, Cincinnati, Ohio—Circular describes the Standard improved special ½-in. drill which is equipped with universal motor and ball bearings.

Link-Belt Company, Chicago, Ill.—Book 650 shows applications of Link-Belt portable loaders for handling coal, sand, gravel, lime, fertilizer and many other loose materials which have to be loaded from the pile in industrial plants. These vary from small portable belt loaders, gas-engine or motor driven, to large bucket loaders of several hundred tons capacity a day.

Western Electro Mechanical Company, Oakland, Calif.—A 26-page catalog describes the load testing devices for alternating and direct current circuits. These include indicating and graphic alternating current line current test sets, direct current load testing equipment, phantom loads and automatic substation equipment.

Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.—Bulletin 680, reprint, describes the Macbeth illuminometer and gives directions for its operation. This portable equipment is calibrated to read in foot candles.

Mercury Manufacturing Co., 4118 South Halsted Street, Chicago, Ill.—A group of bulletins describes the Mercury tractors and trailers.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Publication 3082, entitled, "Cutler-Hammer Electric Elevator Control Equipment," devotes 48 pages to a description of control equipment of various types and gives standard installations as well as wiring diagrams. Several pages are devoted to a discussion of motors for elevator service, motor fuse and wire rating.

Morse Chain Company, Ithaca, N. Y.—A 48-page booklet entitled "A Chain of Testimonials" contains twenty-two testimonials from that many different concerns which show the experience of users in twenty-six industries for driving twenty-five different types of equipment.

The Truscon Laboratories, Detroit, Mich.—Folders describe Stuccotex, a dry powder, which, when mixed with water, is used for painting cement, stucco and masonry even though the surface is damp and ordinary coverings cannot be used.

Gibb Instrument Company, Bay City, Mich.—A folder entitled, "The Heating Machine," describes some of the electrical heating equipment for welding or brazing.

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Founded 1882 as Electrical Review MARCH, 1925 McGraw-Hill Co., Inc., Chicago, Ill

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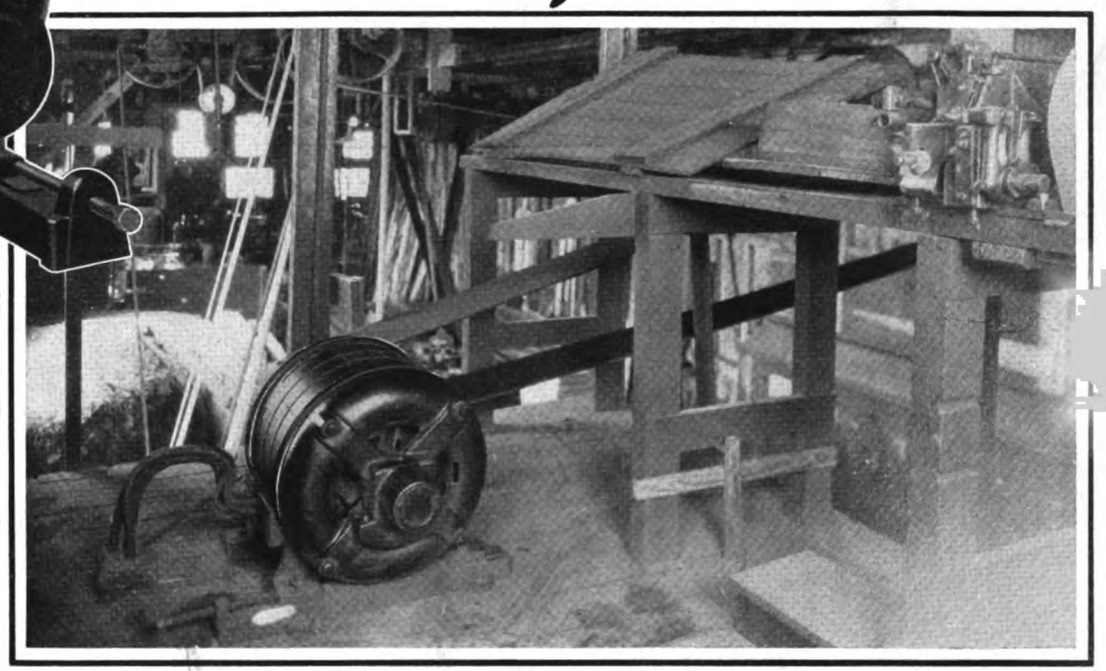
Industrial Engineer

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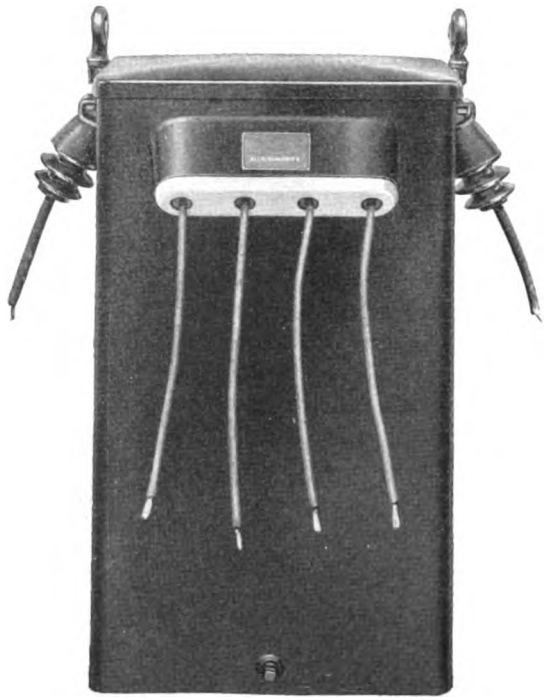
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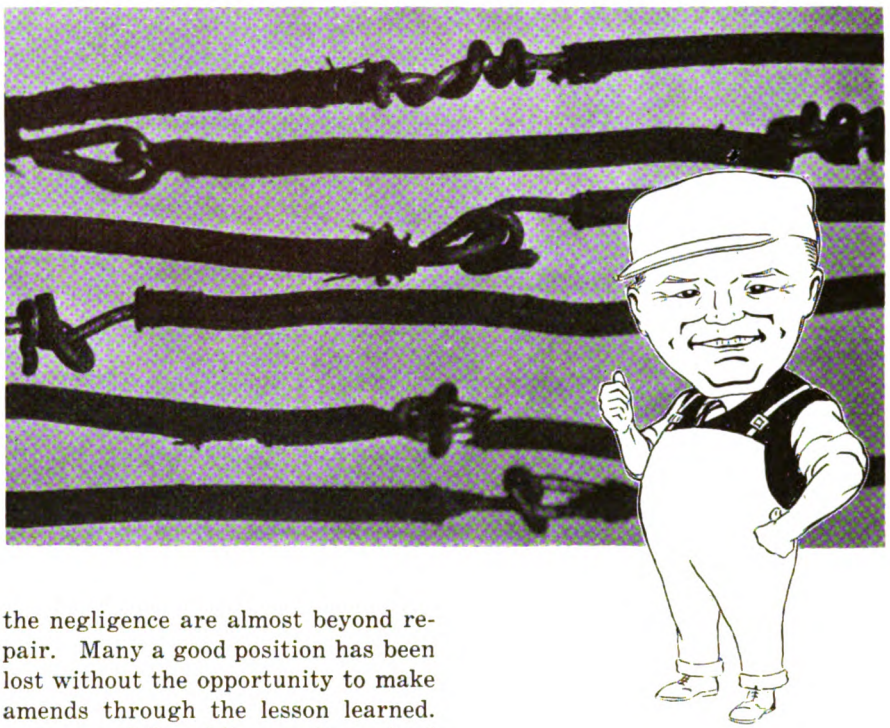
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 83 Chicago, March, 1925 *Number 3*

Pride in Workmanship

Will Cure More Troubles Than Expert Knowledge Will When It Is Carelessly or Indifferently Applied to a Job



MOST folks take pride in doing a good job and setting standards of workmanship that command both respect and admiration. This trait of human nature associated with an active mind and healthy body can be found in presidents of big corporations and downward through their organizations to the janitor who has places for everything and uses them, keeps his own yard clean and worries not about that of his neighbor. Evidences of this kind of pride in work done and responsibility carried show up in many ways. Likewise evidences of a lack of it come to light in equally as many unexpected ways, and always reflect unfavorably on the man whose negligence, carelessness, or indifference allows damaging evidences of poor management or poor workmanship to pile up around him.

Excuses for poor work, sloppy in character or a makeshift even in temporary repairs, never quite compensate for good intentions, and when such work is discovered by others called in to make corrections, the damages to the party guilty of the negligence are almost beyond repair. Many a good position has been lost without the opportunity to make amends through the lesson learned.

Just a little while ago I received the following letter and the accompanying photograph which illustrates all of the points I am trying to bring out. That letter reads as follows:

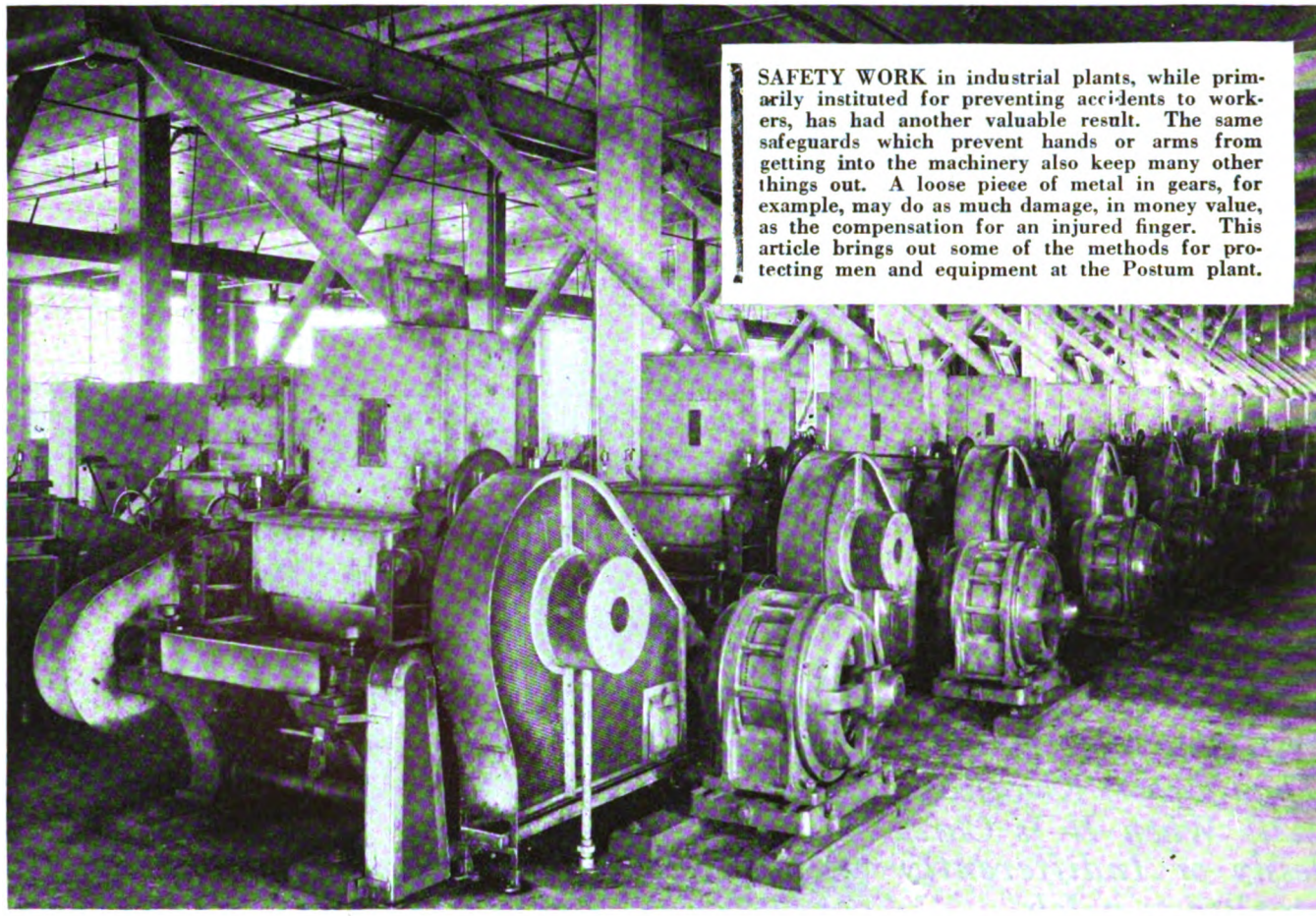
I am sending you herewith exhibits from A to Z on, "How it should not be done." These specimens were cut out of a two-wire line within a distance of 9 ft. 6 in. in a building used for five or six suites of living quarters over a block of stores. The wires are weatherproof and were used to carry the entire lighting of the upper floor.

We were asked to investigate the cause of a very high bill by the landlord's agent and our attention was drawn to a very noticeable hum in a certain location, which seemed to indicate the use of a heater, contrary to the rules of the building. After failing to locate the heater, we cut off the wires and pulled them out. What we found is shown in the photograph and was the cause of the hum. This is the first time in my experience that I have found a hum from such a source, and I could not believe that a human being with normal intelligence would do such a job.

It is hardly believable that any wireman would willfully install wiring in this manner. The party who did the job is not present to justify his case, but it is difficult to imagine what he could say in defense of his standards or workmanship. This picture is mute evidence of gross negligence for which there can be no satisfactory excuses. But the man who supervised this workman is partly to blame. Punishment will not cure such trouble, but pride in workmanship would. It's your job as the boss to develop this in your men and a kind word about a good job as well as criticism of poor workmanship will go a long way.

Practical Pete

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SAFETY WORK in industrial plants, while primarily instituted for preventing accidents to workers, has had another valuable result. The same safeguards which prevent hands or arms from getting into the machinery also keep many other things out. A loose piece of metal in gears, for example, may do as much damage, in money value, as the compensation for an injured finger. This article brings out some of the methods for protecting men and equipment at the Postum plant.

Method of guarding flaking mill in the new Post Toastie building.

In this department the cooked and tempered grain, called grits, passes through heavy rolls which roll it out into flakes. The grain is served through chutes from above and passes on down to the floor below where it is toasted and then boxed. Each mill is individually driven by a 35-hp. motor, through a silent chain. All the equipment is raised from the floor so that it can be more easily cleaned underneath. The top of the guards are of solid metal, while in some cases the sides are open. Any of these guards may be easily removed by loosening a few bolts and they are made substantial enough so that they will fit back into place easily. Small doors are provided where it is necessary to get inside the guards for lubrication. The panel board controlling these motors is shown in an accompanying illustration.

Some Practices That Are

Reducing Breakdowns and Lost-Time Accidents

In a Large Food Products Plant Through Protection to Operators and Machines That Includes Inspection and Safety Precautions

By R. R. THOMSON

General Superintendent The Postum Cereal Co., Battle Creek, Mich.

SAFEGUARDING in the industrial plant has two purposes: (1) To protect the operator or others who may come near and (2) To protect the machinery, as an accident to an operator or others, such as may result from premature starting, may often also be disastrous to the machine. The same safeguard, thus, often serves a double purpose. Because, as has often been stated, "The best safeguard is a careful man," much work must be done toward educating the men to be careful by repeating the safety lesson so frequently that none can forget it.

The new Post Toastie plant is not only provided with carefully planned safeguards but has the advantage of a plant safety organization that functions. While all of the machinery in other buildings in the works is well guarded, the new building has the guards designed and installed as a unit instead of piecemeal or as an afterthought, as is so often the case. Practically all the machines were built in our own shop and the guards constructed as a part of them. This not only makes better-designed guards but also better-appearing guards. Appearance is especially desirable here as many visitors come to the plant annually to see the process of making Post Toasties. All the machines and guards are painted with a heavy coating of gray enamel to match the machines, which are also enameled.

These safeguards are generally made out of Steelcrete expanded metal, 22 gage, with diamond-shaped slits about ½ in. x 1 in. This comes in sheets 36 in. x 120 in. and is cut to shape and fastened with stove bolts to a framework of 1-in. x 1-in. x ⅛-in. angle-iron, on heavy sheet metal cut and formed to shape.

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In some places, as around moving belts, light sheet iron is used for part of the guards to retain any particles of dust which might be thrown out or stirred up by the rapid motion of the belt or chain. Also this solid top on the guard makes it easier to dust and clean and less liable to catch dirt than if it were perforated on top. Cleanliness is an important factor in a food-products plant.

These machine guards are made in the sheet metal shop which has facilities for cutting the expanded and sheet metal, for shaping it and also for bending the angle-iron frames. Expanded metal and angle iron of various weights and gages are kept in stock so that additional guards may be obtained as required on new equipment or when it is necessary to move or rebuild any machine. In addition, each guard is made so that it can be removed and is substantial enough so that when taken off it will hold its shape and can be easily replaced without forcing. This is a point too often neglected in the making of guards but it takes very little more time to make a good guard than a poor one. The legs of the guard which rest on the floor fit into sockets fastened to the floor. This facilitates the removal of any guard as it is only necessary to loosen a few screws. Small doors or openings are provided in all guards where it is necessary to oil or adjust parts on the inside. This makes it unnecessary to remove the entire guard except when making extensive repairs or adjustments of the machinery. Sufficient space is left within the guard to prevent it from rubbing on the belt, gearing or any other moving parts. All safeguards on machinery are built according to the standards approved by the liability insurance companies so that we get a high rating by the inspector which in turn affects the insurance cost because approved guards decrease the risk and the insurance premium.



One of the permanent ladders for overhead lubrication.

In practically all places where continual lubrication is required overhead ladders such as this are built in permanently. In addition to making it easier to oil this elevator drive a special guard prevents the oiler from coming accidentally in contact with the drive.

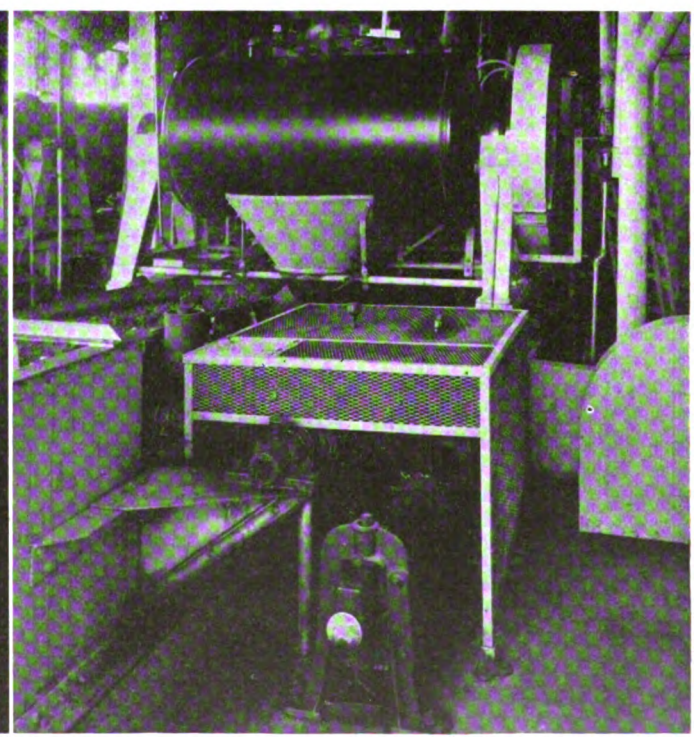
Practically all the machinery in this plant is driven by individual motors, connected by belt or silent chain to the machines. Individual drives are used because they make a better looking room and also stir up less dust than the belt drives. Both of these are important considerations in a food factory. Other reasons for individual drives are greater ease in controlling individual machines and also the better distribution of power.

Special attention is given to safeguards for oilers and others whose duty carries them regularly into dangerous locations, as well as for millwright inspectors and other repairmen who must on occasion also be exposed to an out-of-the-way hazard. Permanent platforms are used

Two other steps in the process of making Post Toasties.

The illustration at the left shows a row of the rotary cookers in which the corn grits are cooked. Notice here particularly the opening in the guard for oiling and also the special "helmet" over the motor to protect it from dripping hot water. A simple strap iron guard protects the wiring connections of the motor. Here, a permanent ladder is set in between each group of machines for the use of the operator or for inspection. The illustration at the right shows another view of the rotary cooker and the drive for the collecting belt underneath, upon which the cooked corn is dumped. In this case, in addition to leaving a door in the guard, grease cup and oil pipe connections are extended up through the guard so that it is unnecessary for the oiler to endanger himself or go to the trouble of opening the guard. Here, two sets of hangers are inverted to form a floor stand and support a short shaft.

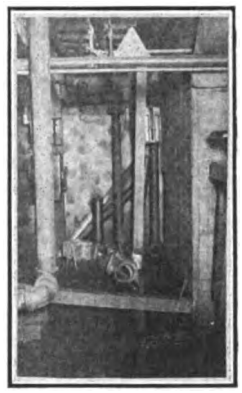




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Four Bulletins Which Teach Safety Lessons

How the Camera and Text Can Be Used to Play Up Unsafe Practices



Watch Your Step.

When a piece of machinery is braced by a stick of timber, as shown in the photograph, even the most careful workman is likely to get a fall. You will notice this beam is just the right height from the floor to catch the lower parts of the shins, and located as it is right in a rather poorly lighted passageway, the wonder is that more injuries were not caused and that those who did stumble were not more seriously hurt.



THINK
of the Other Fellow's Safety.

This apparently was not practiced by the workmen who made the opening, here shown, in the floor of one of our departments, and it nearly resulted in injury to another man.

A foreman in a department where this picture was taken went around at closing time and turned out all lights, the last one near this passageway. Then with his eyes dimmed by the change from bright light to darkness, he started through the passage, not knowing of the hole in the floor, left unprotected by those who opened it during the day. For some reason he took the precaution to feel along the floor with his feet and thus just chanced to avoid a fall.

What a bad injury he would have received if he had gone through the hole into the steam line tunnel, bumping his head on the flange bolts as he passed.

Think Safety for yourself and for the other fellow also.



Bad Business

Tools and material carelessly left on stairways may cause someone serious injury, suffering, and loss of time and money

We must be mindful of the safety of others as well as ourselves. Thoughtfulness will prevent a large proportion of our injuries.

Let's be Careful!



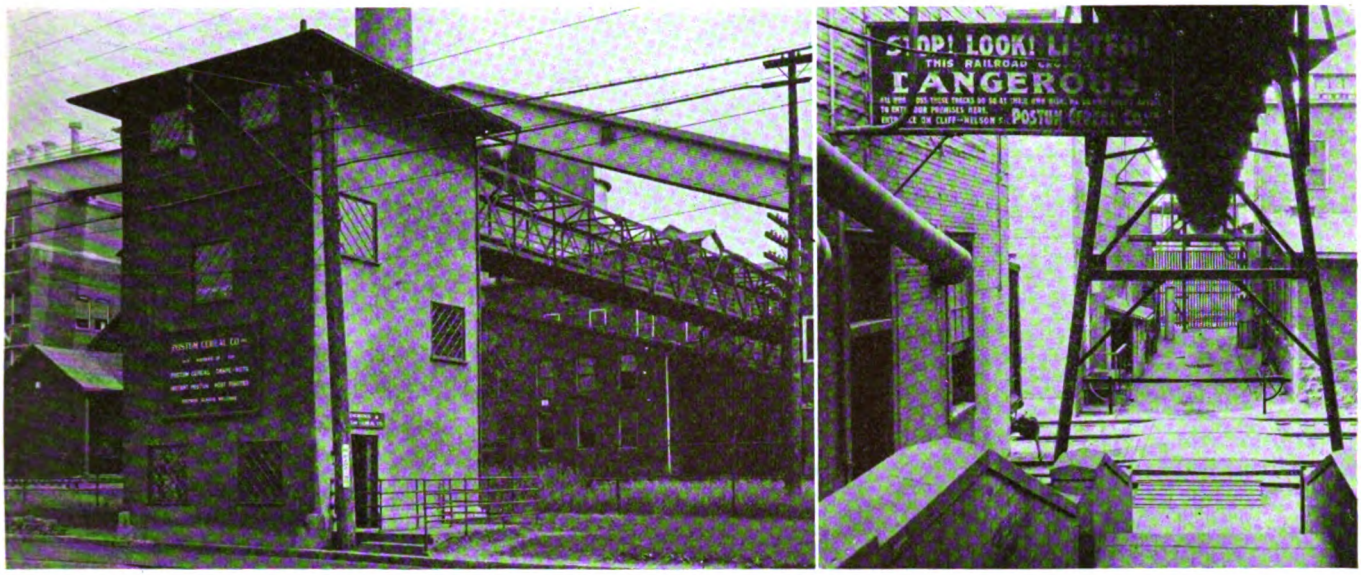
It Happened Just This Way

When someone leaned the six-foot piece of pipe against the sliding gate, he didn't think what the result might be. The gate was pushed back just as a man was passing, and he barely escaped being struck by the falling pipe.

There have been several injuries in the Postum plant on account of brushes, shovels, crow-bars, boards, and other objects which were so placed that sliding doors, etc., made them fall.

Think accident prevention and satisfy yourself that you are not causing the man who follows you to get hurt.

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The entrance to the plant of the Postum Cereal Company and an interior view of the yard.

The building in the foreground is an entrance to the bridge which takes the employees and visitors over the railroad track when entering the plant. The view at the right is taken underneath this bridge facing toward the entrance. Before a worker can step out upon the switch track, he must first lift the gate which is so balanced that it will swing back into position automatically.

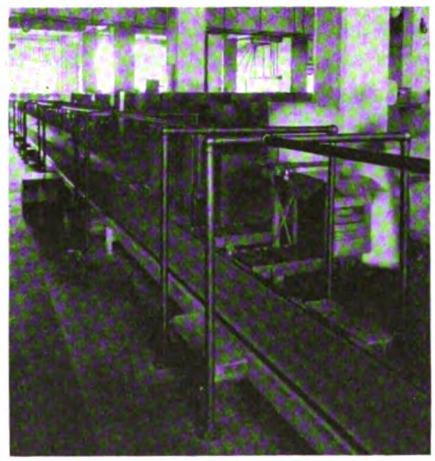
whenever possible, as may be seen from some of the illustrations. These make it almost unnecessary to use ladders for oiling or to build platforms or scaffolds for inspection or repair of overhead motors. Whenever possible, motors are placed on or near the floor so that only a few ladders or platforms are necessary.

In many plants it is the policy to do no more toward providing safeguards for oilers or maintenance workers than may be required by the state code or by the insurance inspectors. The management of some companies relies upon the type of men engaged in this work, realizing that they are operating under somewhat more hazardous conditions than ordinary and so taking greater precautions. The experience and statistics of the accident insurance companies have shown that this is not the case and that even the most isolated hazards may cause a serious accident the first time it becomes necessary for a man to go close to the hazard. Unusual precautions to prevent accidents are taken in our plants.

In one case, for example, as shown by one of the illustrations, the grease cup is extended through the mesh of the guard to the outside so that there is seldom any necessity of going inside the guard. In other cases, similar provision is made for oiling from the outside and so there is less opportunity for the oilers to be injured.

Another function of the safeguards, and one which is too often overlooked, is their value in protecting machinery. A guard around the silent chain, for example, is of almost as much value in preventing foreign objects, such as wrenches, bolts or nuts, from getting between the chain and sprockets as in keeping hands and arms out.

All electrical equipment is likewise thoroughly protected. In the flaking room where each flaking roll is driven by a 35-hp. motor, the motors are controlled in groups of four with a separate panel box for each group, as shown. Here, because only one motor of a group is started at a time, a single G. E. CR 1034 Type NR compensator is connected into the lines for each two groups of motors and their panel boards. The actual starting is handled by a G. E. barrel switch with the compensator coils removed and overload relays mounted in their place. This arrangement made possible a considerable saving in the installation cost. Each piece of starting equipment is identified conspicuously as is also the switch in the panel box, as may be seen from the illustration of an installation.



Guards and cross-overs on a conveyor belt.

When this belt was installed without guards, some of the workers would step on the belt when crossing over. This easily-constructed pipe guard fixes definite cross-over openings. In addition steps are built on a level with the belt and make stepping on the belt unnecessary. A section of a worn-out conveyor belt is tacked onto the steps to eliminate any slipping hazard.

Motors of 5 hp. or under are started with G. E. CR 1038 safety switches, except that thermaloads are added when used in case of remote control.

All panel boards are made in the electrical department to fit the particular operating requirements. When mounted the board shows the location of each motor connected in to it and the size of fuse to be used. This is checked frequently to see that the wrong size of fuse does not get into the panel board. These boards are kept locked and only an authorized person has access to them.

Power is purchased at 5,000 volts, 60 cycles, three-phase and stepped down to 440 volts for power and 110 volts for lighting service. Altogether about 625 motors ranging from ½ hp. to 250 hp. are installed in the plant. All motors are placed and removed by the mechanical department, but all connections or disconnections as well as inspections, oiling and servicing are handled by the electrical department.

All motors are inspected once, and some twice, a day. On his trip, the oiler feels the bearings, inspects belts, looks over all the grounded

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These packing machines are approximately 100 ft. long and all moving parts are carefully guarded.

Here, as in other parts of the plant, all the machinery is set up from the floor so that it can be more easily cleaned underneath. Also, guards with sheet metal tops and expanded metal sides are used. These machines fill the cartons with Post Toasties, close the box and seal it. As the boxes are discharged, they are packed into a large container which is carried on to the shipping room on the belt conveyor shown in another illustration.

static connections, and listens for rubbing rotors. If he hears any sound, he immediately shuts down the motor and inserts a feeler between the stator and rotor and if necessary the bearing is changed at the first opportunity. Also the oiler carries a flash light and looks into the bearings to see that the oil ring is turning. We have found that the ordinary oiler has a tendency to use too much oil rather than too little. We have also found that it pays to employ a higher grade man for oiling than is ordinarily found in an industrial plant.

Once a year the whole plant is shut down and feelers inserted in all motors. Any that show evidence of wear have their bearings changed, as we do not want to risk a shutdown in the middle of the year while the plant is busy and operating 24 hr. per day. During this annual shutdown, the insulation on half of the motors is varnished each year. In that way, all the motors are gone over every two years.

This careful inspection and annual overhauling has resulted in reducing motor failures to such an extent that only fourteen motors required rewinding in a period of about three years.

These rewinds were due to:

Leaky pipes	3
Leaky roofs	4
Use of acid extinguisher	1
Fire	2
Running single phase	2
Shorted coils	1
Metal in coils	1
Total	14

This last failure was due to a piece of metal getting in between a rotor and stator. As a result of this analysis, motors driving cookers and other equipment where steam and water pipes are placed overhead are now provided with a helmet or shield, as shown in one of the accompanying illustrations. This will turn the water enough to protect the motor from any leaky connections.

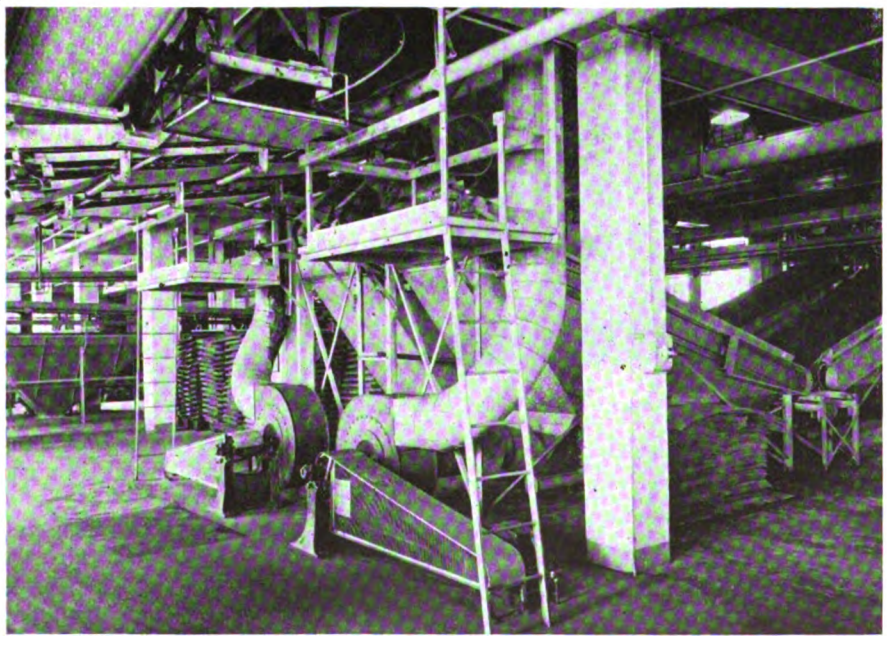
It will be noticed that none of these failures was due to bearing trouble. However, due to the careful inspection and our policy of removing a bearing before it has an opportunity to do damage, a possible forty-nine failures were prevented by removing that many worn bearings. An analysis of the cause of worn bearings shows that forty-one were due to natural wear, two to tight belts and six to unknown causes. Due to the care taken of the motors and the inspections we have found it possible to get along with a comparatively small number of substitute motors. In no case have we more than one extra motor of any size or type.

While these precautions are not ordinarily looked upon as safety practices, nevertheless, the security of continuous operation depends upon them. Without this care, it would be difficult to operate continuously. Interruptions in some parts of the process would result in a total loss of the product.

Educational Advantages of the Plant Safety Department

Even though all new work is carefully guarded as best we know how, experience and time show up new hazards which had not been thought of. One good example of this was a hot return pipe line near a stairway. This was left unguarded as it was not where one would ordinarily touch it, although it was within reach from the stairway. However, one day a man lost his balance on this stairway, grasped the pipe and burned his hand. The pipe,

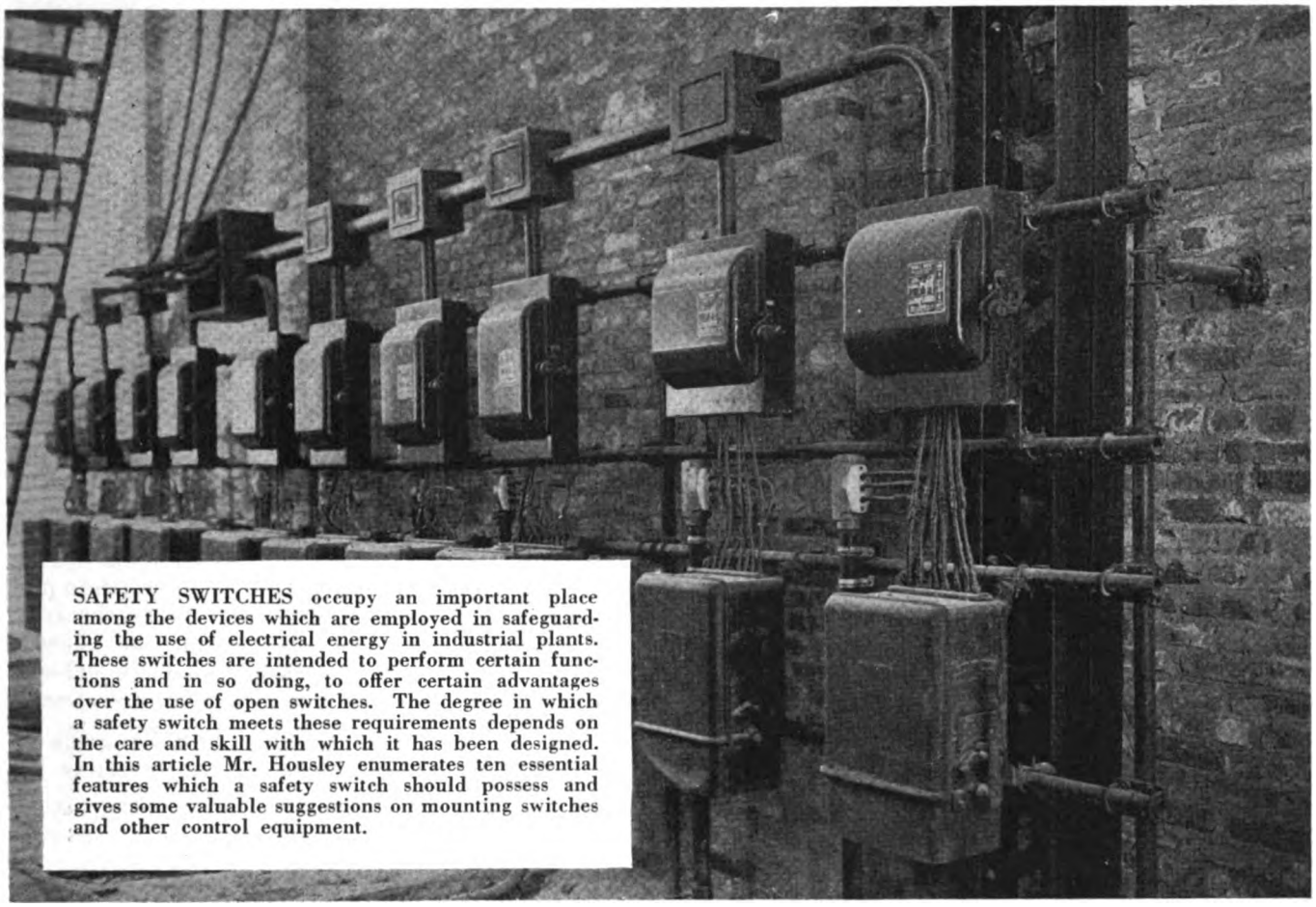
(Please turn to page 160)



Ladders and maintenance platform at the cooling screens and storage hoppers.

The belt conveyors which receive the toasted corn flakes from the ovens on the floor above discharge them upon these cooling screens and storage hoppers. The storage hoppers fill the important function of securing "balance," the big problem in connection with any progressive manufacturing. Magnets over the conveyor belt remove any chance metallic particles. In addition, many other magnets are installed, particularly ahead of the flaking process, so that there is no opportunity for metal to get into the rolls. Also, here are two of the many examples in the plant of permanent platforms and fixed ladders for protection of millwrights and oilers. These are used here not only because of the saving effected in the time of skilled men but also from a safety standpoint. The flakes go from here to the packing machine on the floor below, shown in another illustration.

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SAFETY SWITCHES occupy an important place among the devices which are employed in safeguarding the use of electrical energy in industrial plants. These switches are intended to perform certain functions and in so doing, to offer certain advantages over the use of open switches. The degree in which a safety switch meets these requirements depends on the care and skill with which it has been designed. In this article Mr. Housley enumerates ten essential features which a safety switch should possess and gives some valuable suggestions on mounting switches and other control equipment.

Pump room compensator rack consisting of eight 50-hp. and two 15-hp. safety-switch and compensator units. Eight of the switches are 100 amp. rating and two are 30 amp., 500 volt rating. All switches are quick-make-and-break type. A temporary feed line is shown entering the main junction box. The permanent conduit lines enter the box at the back. The junction boxes above the switches, are for pulling and splicing wires and are arranged to permit removal of any switch as a unit. One end of the conduit leading to the motor is bolted to the rack alongside the compensator.

Practical Viewpoints on the

Essential Requirements of Safety Switches

With the Reasons Therefore and Suggestions on Mounting Them for Safety and Ease in Making Replacements

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.

WITH the rapid and widespread increase in the use of electrical energy in industrial plants, there have also been many advances in safeguarding the use of this energy in the industries coming under the writer's observation during the past fifteen years. Until about 1912 the motor switch and the other knife switches were usually exposed and all wiring was run open. Between 1912 and 1915 some conduit was used and it would ordinarily be found encasing the vertical leads running from the building feeder, mounted on the roof trusses or elsewhere overhead, down to the motor switch. During this period the open knife switch was encased within a wooden box which was made of generous size and lined with sheet asbestos paper. One of these wooden boxes is shown in Fig. 1. A measure of protection was thus provided for the wiring most susceptible to damage and the box was protected against the dangerous exposed switch. Injuries resulting from objects carried by workmen striking the live parts of the switch and giving the men a shock as well as shorting the switch, and accidental closure of the switch, had demonstrated the need of some protection. As the most commonly used building material was wood, the switchbox was made of wood. It represented a distinct advance in the art at that time and helped to reduce accidents and loss.

Wooden Switchboxes Were Fire and Accident Hazards

Consider, however, for a moment just what happened during the period the wooden switchbox was in use. It provided a convenient place for the storage of lunches, waste, oil cans, and similar material possibly because the more timorous persons would not investigate the switch boxes. In time the oil cans would be pushed too far into the box and a short circuit across all leads would result; the workman was invariably seriously burned. Hot contacts would

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set the waste and lunch papers on fire, and the box and the adjacent wiring would often be damaged before the blaze was extinguished. Sometimes a very serious fire resulted. Occasionally in reaching into the box to operate the switch the workmen would grip the live switch blade instead of the handle, with unpleasant if not always serious results. Also, when operating the knife switches, if the men did not always take care to see that the compensator was tripped off when the switch was opened or closed a flashover between phases usually occurred, if the motor was large, due to the heavy arc across the contacts of the switch creating a metallic-vapor path for the current. With a large generating station furnishing the power a serious condition was created. This was not due to the use of wood boxes because the situation was worse when all switches were exposed, but the summary of conditions given above indicated the need for further safeguards.

Early in 1916 several externally-operated, enclosed switches with steel boxes were installed and these switches eliminated about 75 per cent of the accidents mentioned above. The improved box in use today will go far toward reducing the remaining 25 per cent of accidents, where education and proper instruction of the operating men is given. All wood switchboxes then in service were replaced with the new switch and a great reduction in operating delays was noticed. Conduit wiring was used throughout with the steel switchboxes, with all metal parts of the system thoroughly grounded. The rapid deterioration of the open wiring and wooden boxes, together with the low scrap value when the equipment had to be moved and reinstalled, was eliminated by the use of a more metallic construction.

Pipe Framework Replaced Wooden Panel and Switch Supports

This wiring had, up to 1918, been mounted on the same type of wood board which supported the previous layout of wood switchbox and compensator. We did not eliminate flashovers and short-circuits within the steel switch box, but the number and serious extent of burns suffered by the workmen were minimized. Occasionally the wood supporting board or panel would catch on fire from these short-circuits. A further improvement, therefore, suggested itself and beginning early in 1918 all compensators as well as starting switch panels were constructed of 1¼-in. wrought-iron pipe. A very simple rack was developed using three standard switchboard pipe fittings; the floor flange, pipe cross and single panel support. General views of this construction are shown in the headpiece at the beginning of this article and in Fig. 4. For a single or double switch and compensator rack, two vertical standards, four cross pieces and two horizontal wall braces are regularly used. The bill of material for a single rack is as follows:

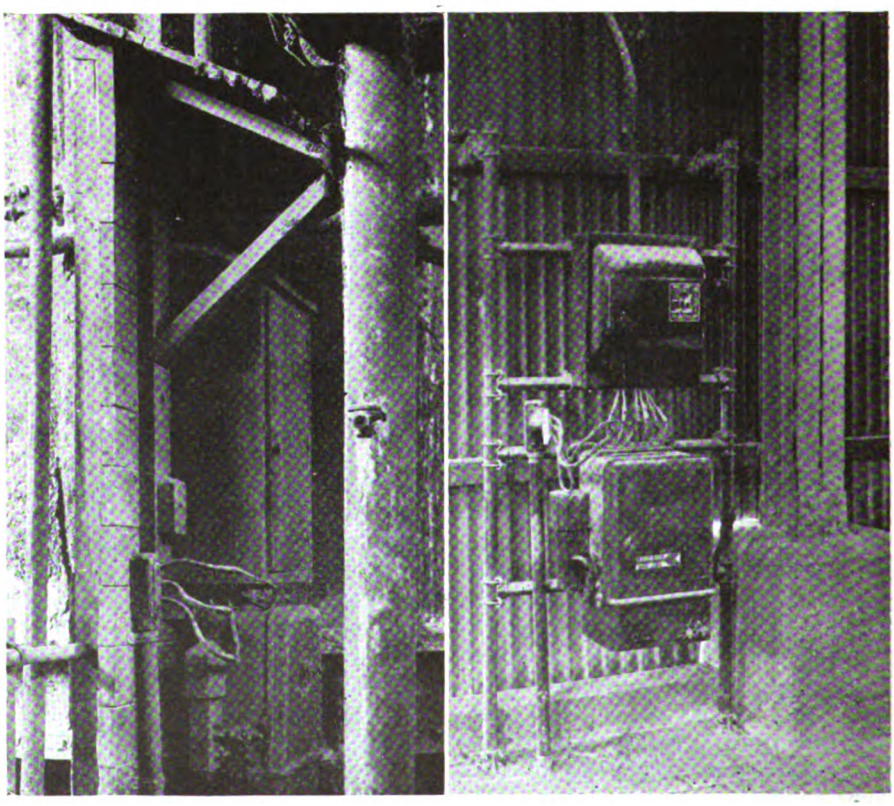
2 pieces 1¼-in. pipe, 7 ft. long.
4 pieces 1¼-in. pipe, 3 ft., 6 in. long.
2 pieces 1¼-in. pipe, 1 ft., 6 in. long.
4 No. 5171 "Three E" floor flanges.
10 No. 5186 "Three E" pipe crosses.
8 No. 1618 "Three E" single panel supports.

The pipe and fittings are carried as regular stock in the storeroom. Each rack has some slight variations in it and the exact dimensions are determined in the field to fit the location. Practically all of the vertical uprights are 7 ft. long. It is a simple matter to slide the cross members up or down to fit any size of switch or compensator. The height of switch and compensator is made convenient for the operator to reach. In groups, sufficient room is allowed between compensators to permit the installation of a large compensator if it should become necessary. We have standardized on a certain make of compensator and use these with all makes of motors. We cannot use overload relays because of corrosion from chemicals.

In the past five years the fireproofing of electrical supports and wiring material has proved its worth in preventing delays due to fire hazards. Building construction has likewise been changed to steel, brick and concrete, giving maximum protection.

Fig. 1—The old and the new types of safety switches, and the method of mounting them.

The illustration at the left shows a wooden box enclosing an ordinary knife switch. The switchbox and compensator are mounted on boards nailed to 4-in. by 4-in. wooden posts. Note the overhanging roof above the switchbox, to protect it from drip. At the right is shown a modern safety switch with compensator mounted below it. This switch is rated at 30 amp., 500 volts and controls a 15-hp. motor driving a rotating drying kiln. The conduits are arranged so that either switch or compensator may be removed and replaced in a few minutes, in order to cut production delays to a minimum in case of breakdown. The construction of the supporting pipe framework is clearly shown in this and some of the other illustrations.



Desirable Operating Features of Enclosed Knife Switches

Returning to switch construction, at the period beginning in 1918 considerable attention was given to remedying the defects which were present in the prevailing types of switches. It was desired to make it necessary to close the switchbox door before closing the switch, and likewise to open the switch before opening the switchbox door. A type of

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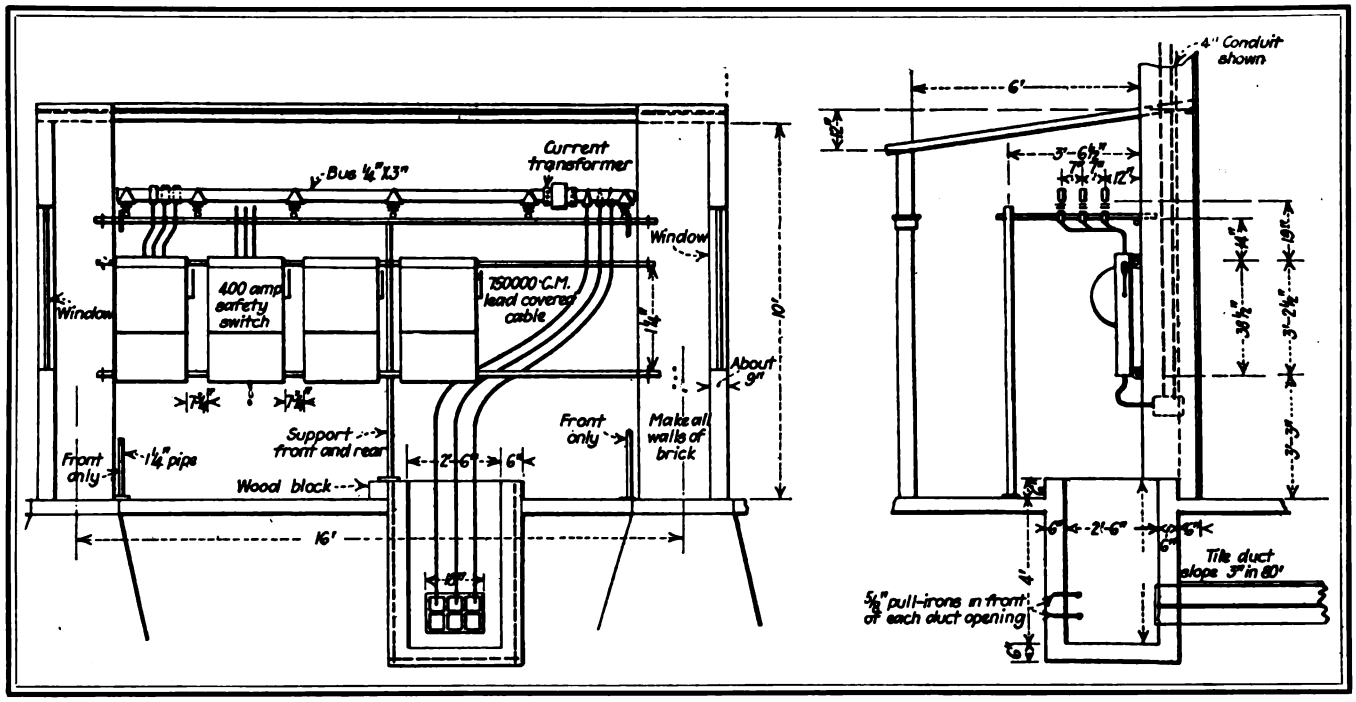


Fig. 2—Details of distribution panel designed for ease in metering and making extensions.

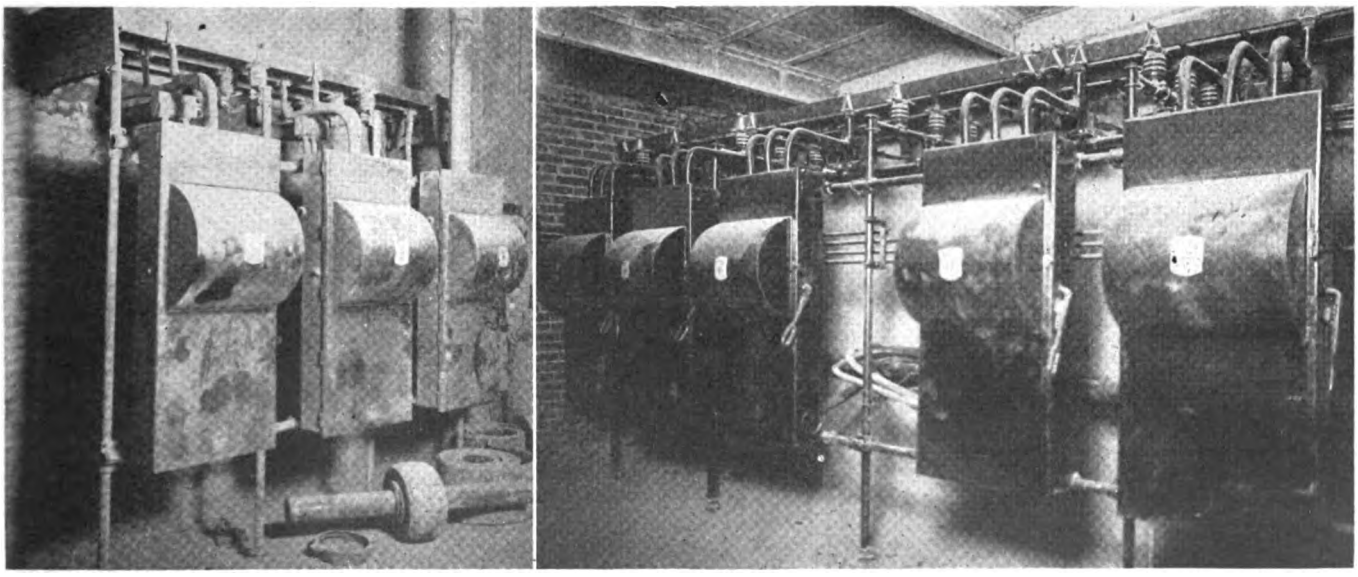
Standard enclosed safety switches of 400-amp. or 600-amp. capacity are mounted on panels supported on a strong, simple pipe framework. The busbars are supported on pipe-mounted bus insulators at the top of the framework. When desired a panel for one or more watt-hour meters may easily be attached to the framework. Switchboard-type current transformers may be mounted in the leads between the bus and the switches, or a bus-type transformer may be inserted at the end of the bus in order to meter the entire distribution center. The circuits are divided, (1) according to the metering necessary and, (2) so that no circuit will be loaded beyond the capacity of a 600-amp. switch. Whenever the load on a circuit exceeds this value a section of bus is put in and a new circuit is run to take care of the additional load.

door and latch was desired which would resist the explosive action of a short-circuit in the switch and not blow open, exposing the operator to the hot escaping gases. A quick-make-and-break attachment was considered necessary to prevent arc-overs when the switch was thrown in with a compensator left in the running position, and to prevent an operator from jogging a small motor with the knife switches. Several devices were developed in the field for attachment to the existing switches in order to keep the door shut when the switch was in and to prevent closing the switch while the door was open. This was done during the years 1918 to 1921. By the latter year the manufacturers of safety switches, having realized the need of the industries for greater safety in operation, had provided safety switches embodying in varying degrees the protection desired.

The writer has always used a compensator type of fused switch with compensators, 60 amp. being the smallest switch used for this purpose. Before reviewing the protection desirable in a safety switch the condi-

Fig. 3—Distribution panels like these combine simplicity and strength with ease of making additions and replacements.

The buses at the top are supported on pipe-mounted bus insulators. The illustration at the left shows a small panel consisting of three 500-volt, 600-amp., enclosed safety switches. The two switches at the left supply 10-40 hp. individual motor drives on grinding mills. The switch on the right is for disconnecting the overhead bus from one source of energy. The bus can also be fed from an emergency source controlled elsewhere. Both lines feed through the same current transformers located back of the right-hand switch. The illustration at the right shows five of six switches arranged as a distribution panel. The switches are rated at 500 volts, 600 amp. and supply six department or group feeders. A feeder from the power house supplies the overhead bus.



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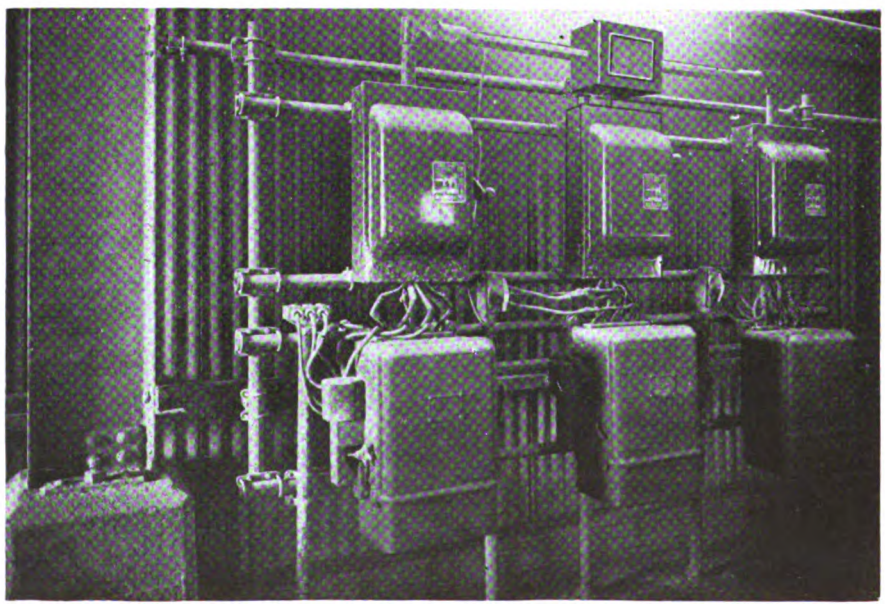
tions to be met in the industry must be analyzed. Where processes must be continuous and where shutdowns without warning involve serious loss, as in the chemical and allied industries, provision must be made for protecting material in process rather than have frequent stopping of motors due to a close margin of overload protection. Pumps and other equipment handling solids suspended in liquids should not be stopped instantly except in cases of short-circuits in the motor or wiring which might cause an interruption to the building circuit or where an overload indicates that the production machinery would be damaged seriously. Where overloads are due to bearing trouble and mechanical friction or disarrangement of the drive the motors must be operated under heavy overloads until that immediate part of the system can be cleared of material and the drive shut down.

With this requirement in mind, fuse protection is used at the motor, owing to the fact that corrosion under some conditions renders overload relays inoperative and because of the dangers attending a "double ground" between the middle wires of two different drives when on different phases, whereby the main building fuses will be blown. Building or department circuits are subdivided at the load-center distribution transformer banks, so that the maximum load on any one circuit will be within the capacity of a 600-amp. fused switch. These fuses protect the wiring between the distribution point and the motor fuses. The transformers and feeder cables are protected at the power station bus by automatic oil switches controlled by Westinghouse CO time-limit relays.

The operating conditions in industrial plants are of necessity reflected in the design of all electrical equipment. Where chemicals in the form of liquids, vapor and solids are handled a certain quantity will get into the switches and equipment. Where steam is present high humidity results and during cold weather all metal and insulating parts are saturated with water and conducting chemicals. In such cases the selection of switches must involve due consideration and tests in the field as to what will happen under operating conditions. The writer has found that under severe conditions a long leakage path from live switch parts to ground is necessary on 440-volt, and desirable on 220-volt, service. The leakage current to ground is able to evaporate the conducting fluids, dry off the insulation and thereby stop the flow of current. The insulation must be such that it will not be affected by the local heat and will not char or carbonize, leaving a low-resistance path. The operating mechanism of the switch should be able to resist corrosion to a certain extent and be arranged so that the moving parts will not have large moving surfaces against stationary surfaces where corrosion could cause a locking action. The general wiring arrangement should be such that any one switch in a group may be removed and replaced without disturbing other switches.

Fig. 4—These switches and compensators control motors which drive induced draft fans for the drying kilns.

The switches are rated at 60 amp., 500 volts and the compensators at 25 hp. In order to save time for the operator in going from one motor to another when starting up or stopping, the switches are grouped and located so that all of the motors are in sight. The construction of the supporting framework is shown clearly in this illustration.



Ten Essential Requirements for Safety Switches

After installing and operating about 2,000 safety switches of various types the writer would suggest the following ten requirements which safety switches for use under severe operating conditions should possess:

(1) The enclosing box should be of heavy gage sheet and should be capable of remaining in alignment over a long period of time.

(2) Latching devices, hinges and operating devices should be strong and rugged. Many switches on the market could well be of more substantial construction.

(3) The operating mechanism should be designed so that corrosion cannot cause binding and failure to operate for that reason. Broad metal surfaces rubbing against each other should be avoided in the design.

(4) A quick-make-and-break mechanism is essential. Operation of the switch should be possible even with all spring parts broken. The switch should be capable of being forced closed in case pitted or dirty contacts prevent the quick-make spring from throwing the blades in full contact.

(5) The method of insulating the crossbar of the operating mechanism and the type of insulation used should be of the highest order. The crossbar should be substantially fastened to the switch blades. The clearance between live switch parts and exposed metal in the switchbox should be as large as possible.

(6) The door latch device should be especially strong to resist the explosive action of short-circuits in the switchbox. The volume of the box should be such as to allow expansion of gases developed, and the box should not be sealed sufficiently tightly to prevent easy escape of the gases.

(7) A slate switch base should be used, affording a relatively long leakage path from live parts to ground. If the distance is short an arc is developed where excessive moisture or chemicals are present; a long leakage path allows the current to dry off the slate base.

(8) The entire switch element with base should be removable from the front of the box without dismantling the enclosing box.

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Some of the

Changes That Have Taken Place in Bearings

Beginning With the Primitive Devices Used by the Ancients and Including the Developments in Sleeve, Ball, and Roller Bearings Up to the Present Day

By L. A. HILLMAN

Research Engineer, Strom Ball Bearing Mfg. Company, Chicago, Ill.

BEARINGS ARE SO commonplace in our everyday life that it is very easy to overlook their importance and not appreciate just how much we are dependent on them. From the time we arise in the morning until we retire at night, we are continuously dependent on them, not only in our business activities but our personal ones as well. Taken in the order of their adoption, bearings are usually divided into three classes or groups: namely, sleeve, roller and ball. This article, which is an abstract of an address delivered by Mr. Hillman before a joint meeting of the Chicago section of the American Society of Mechanical Engineers and the Western Society of Engineers, presents the evolution of each of the three types of bearings. At this meeting there were also two other articles presented on roller and sleeve bearings. These articles together with the discussion developed at the meeting were reported in the January issue of INDUSTRIAL ENGINEER.

LOOKING back and reviewing briefly the early stages of civilization, we find recorded as early as 3,500 B. C. a simple form of plain bearing in a wheel, the latter probably being a slice of a tree trunk with a hole in the center. Later the design was brought more nearly to our present standard by the introduction of spokes, so that in 2,000 B. C. we find war chariots equipped with wheels having a hub, spokes and outer rim.

In all probability both members of these early bearings were made of wood. The next step, although the definite date is not available, was undoubtedly the use of iron for at least one, and possibly both members of the bearing.

With the advent of steel, iron boxes and steel shafts came into common use and for years no attempt was made to improve on this combination, which served admirably for the operating conditions in those early days.

In 1839 Babbitt patented a bearing metal, which still bears his name, made of copper, tin and antimony. The development of plain bearings from then on is more or less familiar to all of you; so we can pass to the next in order of adoption; namely, roller bearings.

Before leaving the subject I want to touch briefly on one recent departure from the old school in connection with plain bearings, which I feel is a very decided step in the right direction. I refer to the rapidly growing tendency to provide perfectly fitted bearing surfaces having the correct clearance at the start through the medium of lapped shafts and burnished bearings, both finished to a high degree. This is a decided contrast to the old method of scraping the bearing to the shaft, fitting it tight at the start and depending on the wearing down of the high spots to provide the proper fit and clearance.

In the early ages masses that were too heavy to carry were transported on sledges or runners—a method we still find in use today among primitive tribes. An ancient Egyptian painting on the rocks of El Bersheh (about 1,900 B. C.) shows this method of transporting a large stone statue. In this picture a man is shown pouring out lubricant in front of the sledge. The ancients not only realized the necessity of lubrication but depicted it in their carvings for the benefit of those who were to follow. A great many users of bearings today would do well to take a tip from the ancients and give more attention to proper lubrication.

It is easy for us to conceive the next step: namely, interposing roll-

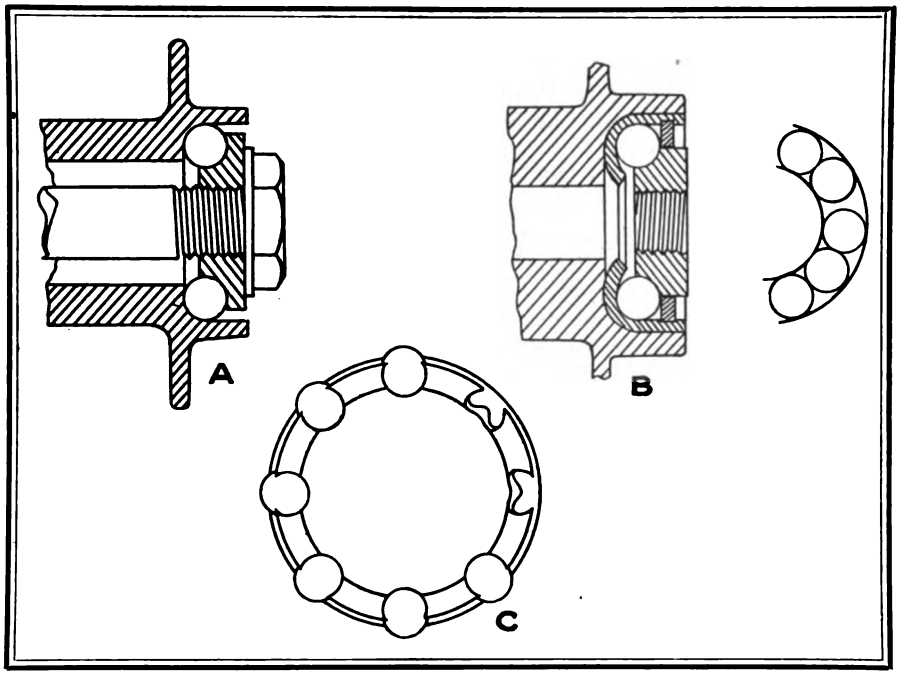


Fig. 1—Cup-and-cone bearings represent an early stage in the development of ball bearings.

At *A* is shown the type used in bicycles, about 1890. At *B* is shown the type first used in the front wheels of automobiles. For years the balls were placed loosely in the races as shown at the right of *B*, but later the retainer shown at *C* was developed to space the balls equally. This quieted the operation of the bearing.

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ers, probably made of tree trunks or limbs, between the ground and the skids. A carving found on rocks in Assyria (875 B. C.) shows how the ancients moved a large statue by using rollers. A large number of rollers were used, showing that the advantages of distributing the load over the greatest area was appreciated even in those early days. Roman battering-rams were moved on rollers in 50 B. C. It is interesting to note that the ancients appreciated the necessity of maintaining a space between the rollers and holding them in alignment—something the later makers of ball and roller bearings were forced to learn over again.

You are all familiar with the rolling device used on sliding doors where a roller runs along a track equal in length to the width of the door, while a pin at the center of the roller travels a track possibly a foot or so in length. This same device was used as a speed reducing device made in 1500 A. D.

As in the case of the plain bearings, although the principles of rollers were understood and their advantages appreciated, they were used only in crude ways until the latter part of the 19th century when demand brought about their further refinement and development.

We find no reference to ball bearings in the early ages of civilization. Even though their advantages may have been appreciated, the early workmen were probably confronted with the same problem which perplexed the experimenters in the 18th and 19th centuries: namely, that of making steel balls. Not until Hoffman developed a process during the last few years of the 19th century for making steel balls to remarkably close limits of size, did the ball bearing really get its start.

The oldest reference to ball bearings which the writer has been able to find is a patent for a ball-bearing wagon axle taken out in England in 1794. This is especially interesting and was undoubtedly far ahead of its time. It is in many respects the same as bearings designed as ideal 100 years later.

Another early application of ball bearings is the use of balls in a caster, to facilitate the turning of the caster roller around a vertical axis. A patent was taken out on this in England in 1820. It is interesting to note that the advantage of keeping the balls separated by means of a retainer was appreciated then.

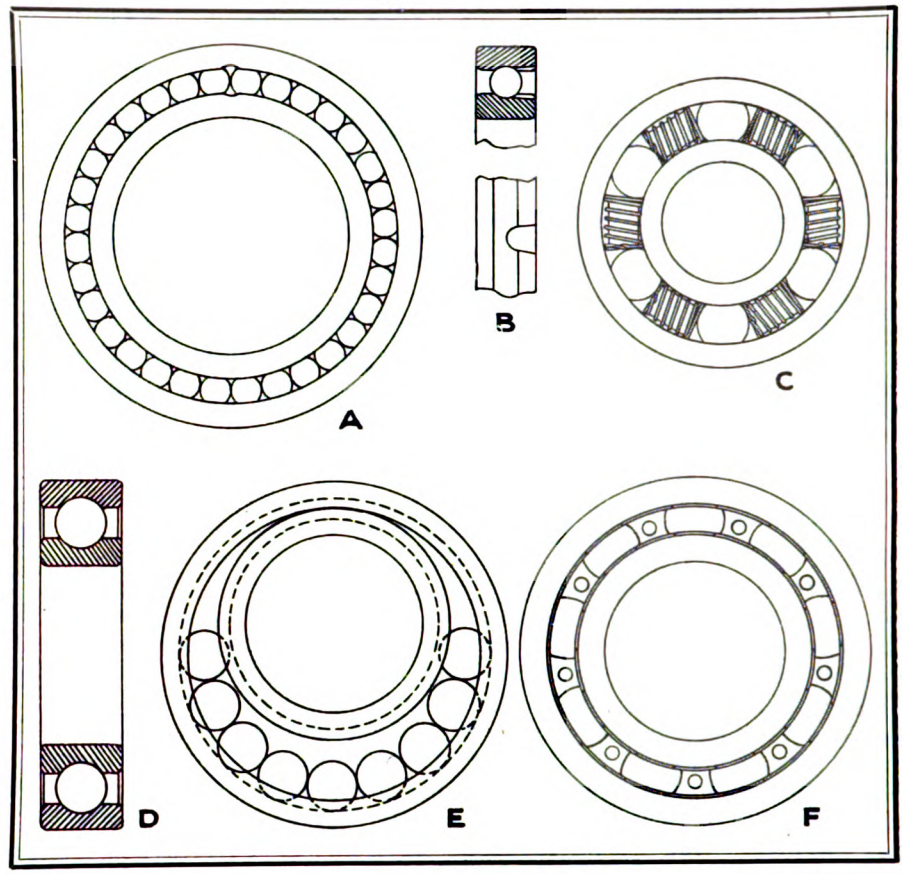


Fig. 2—Full-type, spring-type, and Conrad-type bearings.

At *A* is shown a full-type ball bearing. Only a very small clearance was left between the balls to prevent them from crowding and locking the bearing. The balls were assembled in the race through the filling slot shown at the top of the bearing. Details of the filling slot are shown at *B*. At *C* is shown a ball bearing having a spring-type separator. *D*, *E*, and *F*, show the type of separator used in the Conrad type of ball bearing. At *E* is shown the method of putting the balls in the raceway.

The next step in the development of ball bearings came soon after the invention of the bicycle and was in the form of cup-and-cone bearings. This type is still in use today, not only in bicycles and motorcycles but also in applications where the loads are not severe and where cost is a factor. In the early days of the automobile many cars used them as front wheel bearings. For years the balls were placed loosely in the races, but later retainers were developed to space the balls equally and maintain their relative position to each other. These retainers served both to quiet the bearing in its operation and to facilitate the assembly and disassembly of the balls in the bearing.

These two types are illustrated in Fig. 1. At *A* is shown the type used in bicycles; at *B* is shown the type use in front wheels of automobiles. The retainer with balls inserted and which is mentioned as a later development is shown at *C*.

Properly designed, installed and cared for, they served their purpose admirably. The one outstanding disadvantage is the fact that they are adjustable. Because of this their reputation suffered at the hands of those who did not understand their proper adjustment.

Difficulty was also encountered because of the fact that proper steel from which to make the bearings was not available in the early days and it was also necessary to keep their costs down in order to compete with plain bearings.

The first use of ball bearings in bicycles was in the early 90's and as heretofore stated, these bearings were of the cup-and-cone type. The bearings were amply large for the service imposed and the results obtained contrasted so favorably with those experienced with plain bearings that immediately attempts were made to apply the same design to other and heavier forms of service, such as the wheels of heavy trucks, drays, and the like. Results were far from encouraging—some applications worked fairly well; some were utter failures.

Fortunately, the failures were analyzed as being due to improper materials and design, and not to the basic principles involved; so that instead of dropping the problem as hopeless, those of vision set about

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correcting the faults and attaining success.

Hoffman went to England where he interested capital in the manufacture of balls and it was evident from the results obtained that balls of good quality and a high degree of accuracy could be made.

In 1896 the German Small Arms & Ammunition Co. employed Professor Striebeck to investigate the subject of ball bearings, as they had decided to go into the manufacture of balls and ball bearings.

Professor Striebeck's work really marks the start of ball bearings as we know them today and much of their success is due to the fact that he did the task assigned to him with characteristic thoroughness. Many of his deductions have proven to be sound and still hold good today.

The first bearings were of the full type, so called because the races were entirely filled with balls, a small clearance being left as shown at *A* of Fig. 2, so as to prevent the balls from crowding and locking the bearing. The balls were assembled between the races by means of a filling slot shown at the top of the race. This slot was ground not quite to the center of the ball track so that the slight shoulder over which the balls had to be forced served to prevent them from coming out when the bearing was in operation, or if the bearing should be mounted on a vertical shaft with the slot opening downward.

This type of bearing was manufactured by several companies for years and gave reasonably satisfactory service. Some bearings were made with a piece of steel inlaid in the filling slot and held in by means of a screw, for it was found that after the bearings wore in service there was a tendency for the balls to drop out of the filling slot. This scheme was soon discarded, however.

The full-type bearings, aside from the filling slot objection, had several other disadvantages. Since there was a slight space between the balls the bearing was noisy in operation for the same reason as was the cup-and-cone bearing, as has been previously explained. This was particularly true if the lubricant was of a thin grade. Since the balls were traveling in opposite directions at the points where they came in contact with each other, flats or equators were worn around their circumference after which they were unfit for satisfactory operation.

Although it was appreciated that to provide a means to prevent the balls from coming in contact with each other, meant a few less balls and therefore a sacrifice of some capacity, the demand for a silent and more satisfactory type of bearing prevailed and various means were adopted to space or separate the balls equally around the race.

It would be out of the question to cover all the types and kinds of separators developed and it is probably unnecessary to discuss them as only a few have survived.

One of the earlier types was the spring type shown at *C* of Fig. 2. This was finally discarded because after the tension of the springs weakened there was a tendency for them to drop out of the bearing and either allow the bearing to collapse, or else the springs lodged in some of the other parts of the mechanism, such as gears, and caused damage.

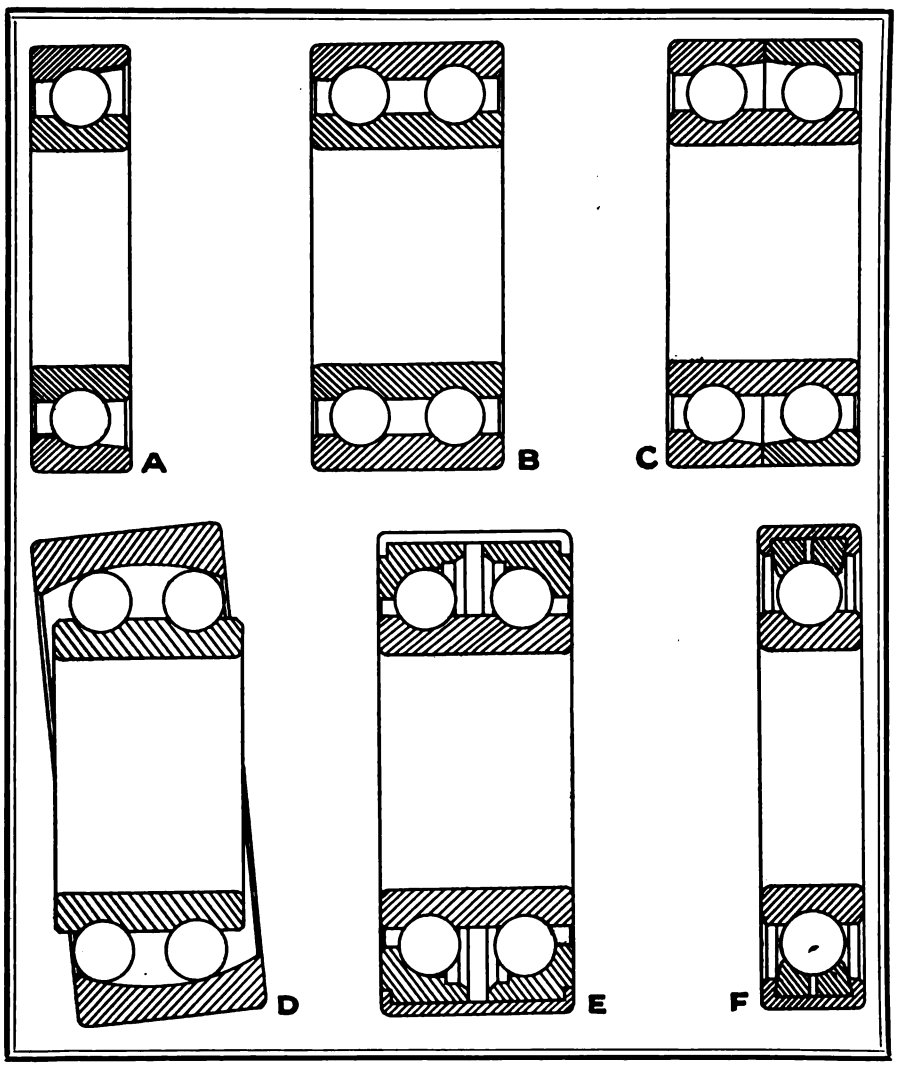
Finally, cast bronze or sheet metal retainers were developed which were of unit construction and which, in addition to spacing the balls, had the added advantage of preventing the balls from dropping out of the filling slot.

The Conrad type of bearing patented in 1906 and 1907 is worthy of consideration because it is the best all-purpose radial bearing as yet developed. The patent covered a bearing in which the inner and outer races were uninterrupted in any way and were of the same cross section throughout. It also covered the method of assembling the bearing. This bearing is shown at *D*, *E* and *F* of Fig. 2. The quantity of balls used was just enough to fill half of the raceway when the balls were placed in the raceway in contact with each other.

To assemble the bearing the outer and inner races were placed in the

Fig. 3—Angular-contact type of bearing and types of bearings having patented features.

At *A*, *B*, and *C* are shown angular-contact type, ball bearings. *D* is a self-aligning type which permits of a considerable degree of misalignment of the shaft. *F* is a single-row bearing with a 2-piece outer race retained by a soft steel shell spun in place. *E* is a double-row bearing in which the outer race is made in two sections and held in place with a soft steel shell spun down on the sides. The bearings shown at *E* and *F* have 3-point contact of the balls and races.



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position shown at *E* of Fig. 2 and the balls put in through the opening at the bottom. The inner race was then placed concentric with the outer and the balls equally spaced. The retainer was then assembled the same as in any other type.

Although it appears that the carrying capacity of this bearing will be greatly lessened by the considerable decrease in the number of balls, as compared with the filling-slot type, this decrease in capacity is not exactly in direct proportion because the uninterrupted raceways of the Conrad type add decidedly to its ability to carry loads. Thrust loads in addition to radial are often carried on radial bearings and in the type with the filling slot, this causes ball interference with the edges of the filling slots, resulting in noisy operation and failure. These difficulties are not encountered in the Conrad type because of the uninterrupted races that are provided for the balls to travel in.

So today we have as survivors of the development of radial ball bearings, the cup-and-cone type, the full type, the notched type with retainer and the Conrad type, all of which have been explained. In addition we have the angular-contact type shown at *A*, *B* and *C* of Fig. 3, which is nothing more than a modification of the cup and cone—some designs are made so they are readily disassembled; others are held together by means of a slight shoulder. Practically all of these are made in double row as well as single row types.

There are a few types with patented features. The first is a self-aligning type shown at *D* of Fig. 3, which permits of a considerable degree of misalignment of the shaft with the frame supporting the outer race of the bearing.

At *F*, Fig. 3, is a type of single row bearing with a 2-piece outer race held in place by a soft steel shell spun in place. This type has 3-point contact of the balls and races, one on the inner and two on the outer race.

At *E*, Fig. 3, is shown another type made only in the double row, in which the outer race is made in two sections and held in place with a soft steel shell that is spun down on the sides of the races.

Early ball thrust bearings were made of two hardened steel plates with surfaces ground flat. The balls were held in proper position by means of a retainer. This type is still in use today where the loads are light and where an inexpensive bearing is required.

The first retainers were so designed that the balls tracked in one single path. As this threw all the load on a very small area of the races, retainers as shown at *A*, *B*, and *D* of Fig. 4 were resorted to in order to distribute the area of contact as much as possible over the face of the race.

It soon became evident that even with the new retainer, designs of the flat-disc type were not satisfactory for carrying heavy loads, especially at the higher speeds. So the next step was the grooved type. Many different kinds and types of retainers have been devised for use with this type of thrust bearing, but a pressed-steel type of the design shown at *E* of Fig. 4 seems to have proven the most satisfactory.

Another source of difficulty with the early thrust bearings was traced to misalignment of the parts in which the bearings were mounted. One can readily see that in order to have the load equally distributed on all the balls at all times in a bearing such as shown, not only must the two outer surfaces of the bearing be parallel but the parts in contact with them as well.

In order to overcome this troublesome feature, the outer surface of one race of the bearing was made spherical as shown at *G* in Fig. 4. In most cases the manufacturer supplied an extra ring or seat which eliminated the necessity of the user turning a spherical seat in the part where the bearing was to be mounted.

There is very little further to be said in regard to the development of thrust bearings. Some of the more intricate types are merely combinations of the simpler ones.

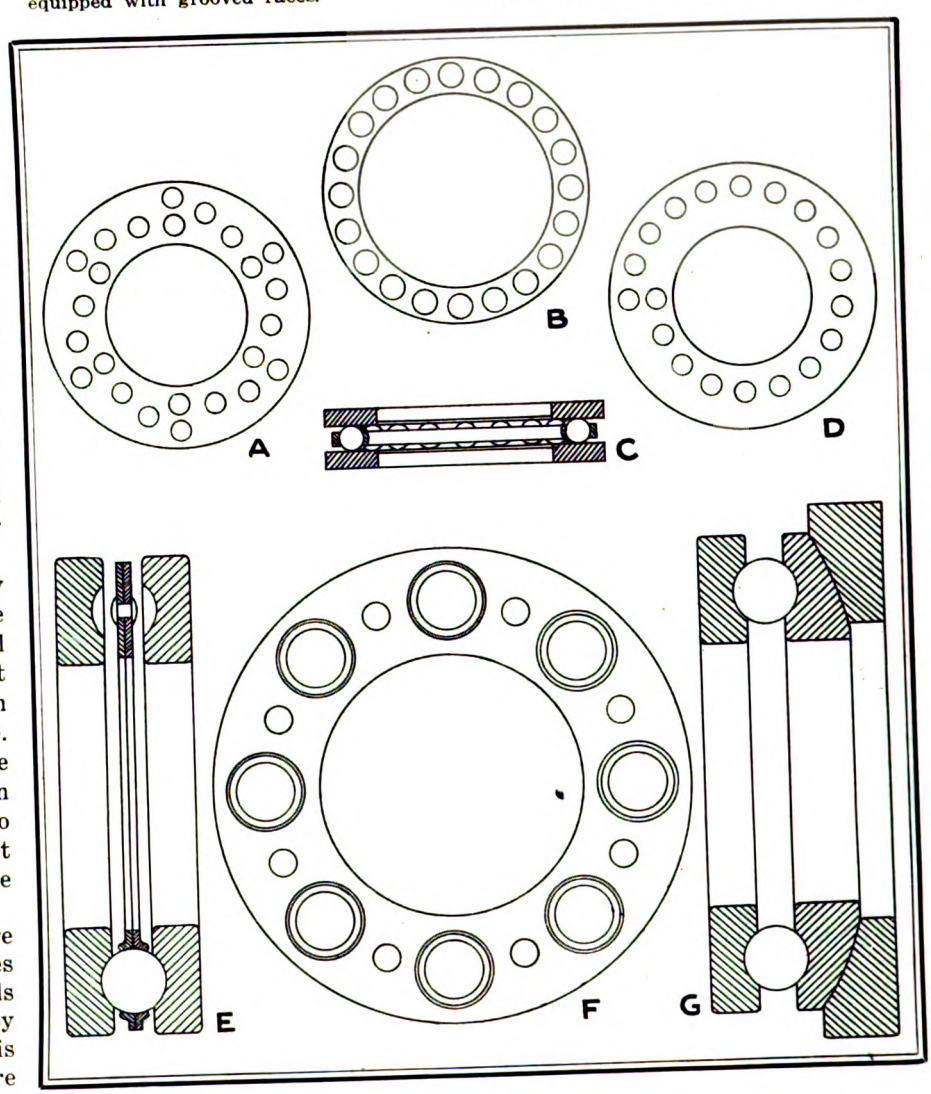


Fig. 4—The ball retainers for thrust bearings were first designed so that the balls tracked in a single path.

As this threw the load on a very small area of the race, the retainers shown at *A*, *B* and *D* were designed to distribute the area of contact as much as possible. At *C* is shown the flat disc races first used with thrust bearings. These were replaced with grooved races as shown at *E*. *F* is a pressed-steel type of retainer. *G* is a self-aligning thrust bearing that is also equipped with grooved races.

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Things the equipment inspector for a manufacturer looks for and some of those that he finds

* * *

Assured that he is going on a still hunt for trouble, where and how will he find it?

* * *

His advice from the Boss is—Remember that 90 per cent of electrical trouble is mechanical—Beware of simplicity in looking for trouble—Be an engineer first, but a diplomat always

Reminiscences of a Trouble Shooter for a Machinery Builder

Sketches from an interview by

Practical Pete

I HAVE a friend, who is an erecting engineer with a large machinery builder, whose knowledge I respect and whose experience I truly envy. He just knows what he knows and the best of it is that he is anything but tight with his information. Furthermore, he knows how to impart it in a way that is easy to understand. To listen to him relate his tales of woe today and of bygone years places you in that frame of mind where you can picture some fast stepping around just where that action is required and a scowl and that "mind your own business" look when the inquisitive guy butts in with foolish questions at the wrong time, which time is usually a period of deep thought and apparent concentration over a blueprint that is all wrong.

Recently I got hold of this fellow whom we will call "Ed" for short and got him started on some memorable experiences and we sat, as many of you have done when you meet a real trouble shooter, and just "chewed the rag" over the worst jobs we ever tackled, and the things that were bumped into without intention, also sometimes with intentions and some doubts and guesses that were carefully concealed.

What Ed told me was so good in spots and places that I am going to set it down here as best I can from the notes that were taken as he went along from one thing to another.

In the beginning, as a starter I said, "Ed, tell me some of the things you look for when performing in the role of inspector, and some of the things you have found."

"Well," said Ed, "it has been my pleasure to have been on both the inspector and inspected ends of such a detail. Before becoming an inspector and being confined strictly to the inspected end, I often wondered what information these men looked for. Now I know. For the benefit of those who may be in the wondering state of mind still, I will be glad to relate a few experiences of my own as an inspector for a manufacturer.

"For instance, I recently came in from an inspection job which had to do with the change-over from direct current to alternating current and the consequent sale of the direct-current apparatus, including switchboards, buses, generators, and all the necessary apparatus that was installed in a substantial, direct-current generating station. This apparatus had been in service for nearly 12 years. The purchase price I do not know. Whether it was a small fraction of the original cost or the present-day cost, was immaterial to me from an inspection point of view, but I did know that about 1,500 miles away was a buyer who knew that this apparatus had been in active service for nearly 12 years and if he was in any sense of the word a practical man, he could build all kinds of illusions as to the condition his purchase might be in.

"An inspector must keep many things in mind on such a trip. In this particular place the firm selling the material was our customer. The purchaser had no connection with us. A biased report favorable to our customer would make us responsible for defective machinery and also lose



WHEN MAKING REPAIRS or replacements it is often necessary to have some apparatus, part of a machine or even a whole plant, inspected by a competent engineer from the manufacturer's engineering department. The fellow who is assigned to such work has no easy job, for he must be a good engineer, first, a man with practical experience, second, and a good-natured diplomat all the time. He must listen and say nothing sometimes and say nothing and be deaf at others. But never can he give up on a job and say he's stuck. He may go back to his works for additional blueprints or special instruments but his self-respect and his confidence to do the job must never permit him to leave a job until it is operating free from the troubles he was called to investigate. The things that I have related in this article are no fairy tales; they have actually happened just as set down and been handled by a real trouble man who meets all the qualifications above enumerated. To those who have a perfectly good reason to want it, I shall be glad to furnish the address of this trouble-man, but for the time being he is just my good friend who has told me these things in confidence and for the benefit of those who are in a position to profit by the information. If it bores anyone else they don't have to read it. Moreover, if it steps on the toes of any one, they don't have to holler nor tell who they are.

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the possibility of securing the second party as a customer in the future. On the other hand, should the machinery be in such condition that an unfavorable report would be necessary, the inspecting engineer would have to be very tactful lest the actual customer and the prospective customer be lost. In all events, it is better that the inspecting engineer be as ignorant as possible of the monetary considerations and confine himself to engineering only—unless diplomacy can be considered within the scope of our profession."

"I have never been on the inspecting end," I told him, "but always on the inspected end, as you call it, and I know that you people who have something to sell sometimes run up against some tough customers. Tell me something about the kind of reception you get when you arrive on the job."

Then with a twinkle in his bright eyes, Ed started in: "You know, that old quotation of school days occurs to me now and if my memory serves me correctly, it goes as follows: 'Methinks the gentleman explains too much'—leastwise that is the application I mean it to imply. And how well it applies to contact with people who have something to sell, especially those who are particularly desirous of making a sale and more especially to those who would like to get the better of the bargain.

"One type of customer friend meets us at the train, takes us to the hotel, then to his office and from that time until we leave he or his lieutenants are right with us to explain this or explain that, or as the case may be, to condemn this or that as the occasion demands. It is mostly praise and take it from me, they do it to perfection, but the engineer makes his report notwithstanding. Then we meet another type of customer friend who extends a friendly greeting, chats a bit and then goes about his business, either to show us the apparatus in question or turns us over to his lieutenants with instructions to assist us all they can or with no word to them at all, if he believes them capable of assuming their responsibilities.

"From this you may assume that there are two kinds of persons and they are the ones that I have listed above. In the first case the person may turn out to be a real, good, likeable chap who has a misconceived notion as to helping in lending a hand, while the second may assume his rather distinguished business air and then have a nicely prearranged schedule to get something on the inspector to cause his report to be erroneous.

"Now, an engineer is human and is likely to err, but not to my knowledge have I met, or do I know, a competent engineer who would make a biased report. In the first place, a good engineer would place his engineering ability above anything that would at some future date be of hindrance to his ambition and, besides, I think all of us possess that little spark of celestial fire called 'Conscience'. But errors are still liable to creep in and my purpose in mentioning this is to point out that if an error is made, it can in all probability be charged to an oversight in the great majority of cases; to lack of engineering ability in the second place; and last, but not the least, to misleading items that have caused a poor report. The last can be charged to the engineer. Generally speaking, engineers representing a manufacturer are men with good, practical engineering ability, capable and self-reliant. They have a good understanding of human nature and are four-square."

"Besides the operating conditions and facts you find, what else do you think an inspector should include in his report?" I asked.

"I am glad you mentioned that," Ed replied, "and I can best answer the question by again referring to the things I ran into on the particular job already mentioned. When I was called in to make that inspection I was greeted as one gentleman would greet another, given a pass to go anywhere in the works, told from whom I might obtain particular information and where I might find these persons. To make errors less liable the names were written on the pass and I was further instructed to get about the huge plant without getting in all the dirt.

"The master mechanic was found in the building I was directed to and after giving introductions to a part of his immediate force, he located the chief electrician and in the *unobtrusive* company of these two gentlemen, a complete inspection was made.

"As stated before, these units were in active service nearly 12 years; sometimes (as explained by the chief) as long as four months without a shutdown, and the condition I found them in was just as they had been shut down about six months previously when the plant was changed to alternating current. The equipment was dirty in many respects—a dirt that could easily have been cleaned off since the units were last shut down—but underneath were signs that indicated that the exterior where operating cleaning was possible, was not a sham. In other words, it showed all care and consideration that could possibly be given a continuously-operating piece of machinery.

"The commutators were in excellent condition, turned twice, brushes accurately fitted and showing signs of good service, bearings had 0.010 in. clearance on the original set, with a good, clear oil coming from them, foundation good, all bases and pedestals securely bolted and shimmed, switchpoints, busbars and other movable contacts not burned, in clean condition, etc.

"The above indicates that a further account of this would be monotonous, for other equipment and parts were as indicated in the foregoing, just as the units were shut down and no attempt made in word or work to make the machinery appear to be anything other than it was: namely, good machinery that had given good service, the kind of service the engineers did not like to part with.

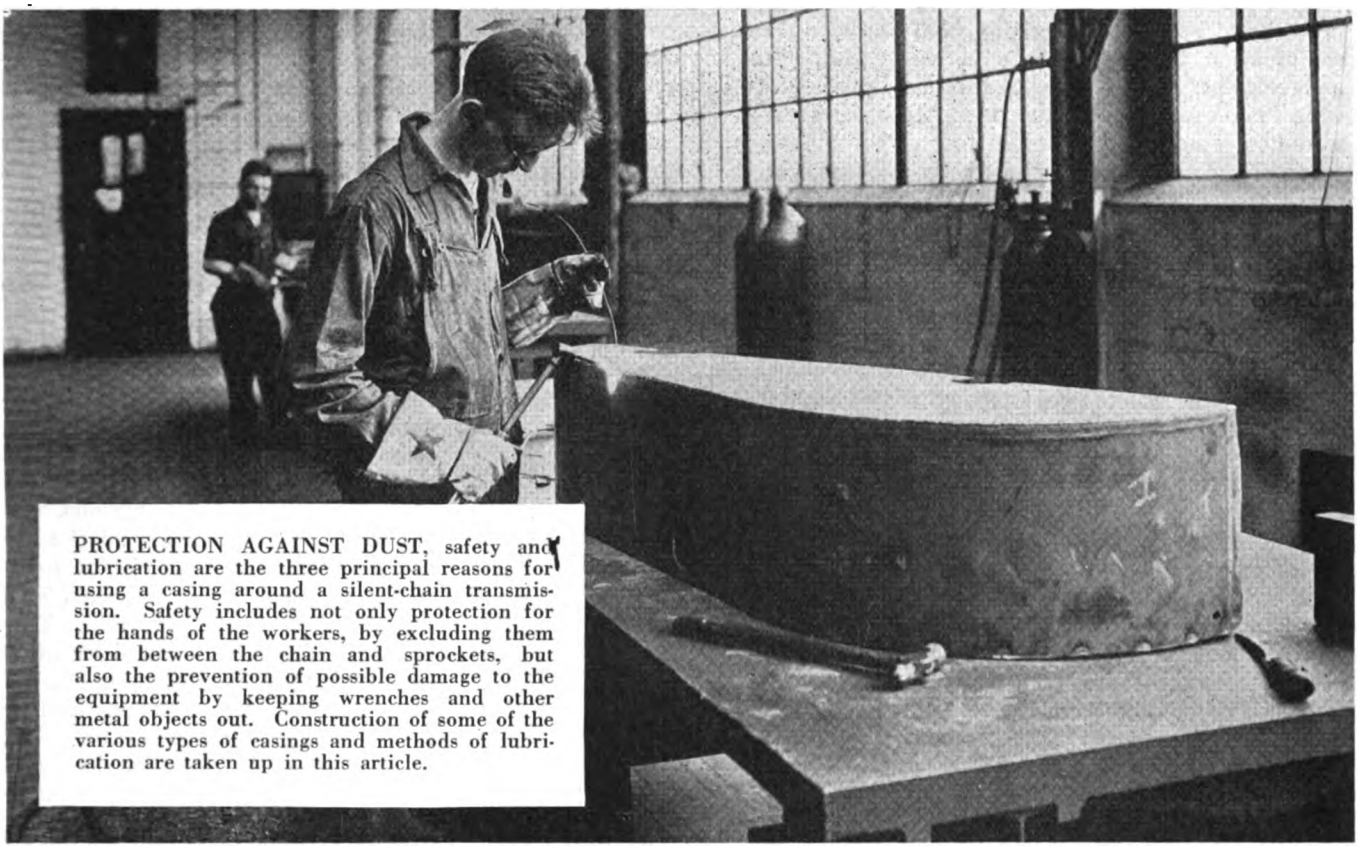
"Let us now look behind the scenes, as the inspector always does. Here was the master mechanic in his place; the chief electrician about his business, but easily called. Both of them were confident and capable-appearing men. A talk with their operators disclosed the fact that they had been in their positions for a number of years. A trip about the works showed that everything seemed to be in its place, machinery operating satisfactorily with minimum noise and apparently repairs were well made by understanding workmen. Harmony and satisfaction seemed to be the predominant factor in men and machines and this was borne out by the mute testimony of the apparatus that they had for sale. Could one believe the machine's appearance if anything but harmony was apparent? And is not this information worth just as much in an inspection report as cold engineering data and conditions as found?"

"But all the plants you inspect are far from that condition, I imagine from what I have seen," I interjected.

"You are dead right," said Ed.

(*Please turn to page 161*)

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PROTECTION AGAINST DUST, safety and lubrication are the three principal reasons for using a casing around a silent-chain transmission. Safety includes not only protection for the hands of the workers, by excluding them from between the chain and sprockets, but also the prevention of possible damage to the equipment by keeping wrenches and other metal objects out. Construction of some of the various types of casings and methods of lubrication are taken up in this article.

The casing is built up here by welding the corners with the oxyacetylene flame torch. It is not necessary to use angle iron to strengthen the casing, if it is properly welded.

Practical Methods of

Enclosing and Lubricating Silent Chain Drives

To Obtain Long Life and Continuous Operation With a Minimum of Attention When Installed in Industrial Plants for Connecting Motors to Machines or Lineshafts

By PAUL WHEELER

Engineer, Link-Belt Co., Cleveland, Ohio

WHEN considering the installation of a new power transmission system or the replacement of an existing one, silent-chain drives possess qualities that merit consideration. Silent-chain drives were originally designed for power transmission where neither belts nor meshed gears were practicable. However, they have completely outgrown this limitation in industrial usage and are today employed in many plants for power transmission service.

During the period of development, however, silent-chain drives were not installed where excessively abrasive atmospheric conditions were encountered, such as in clay-working plants, cement mills and other similar industries, until the universal application of the drives had been proven. The result was the slow recognition of the necessity of dust-proof, oil-tight casings for the drives when used under such conditions. However, the necessity for such a casing is frequently underestimated by users who have in many cases failed to enclose the drive in a casing when the installation was to be made in a grain elevator, cement mill, brick plant or other unusually dusty place.

There are three underlying reasons why users of silent-chain drives should insist on proper casings for this type of power transmission equipment. These reasons are: (1) To keep out dust; (2) to retain oil; (3) to increase safety.

The reason why it is necessary to keep out dust is obvious. Under many industrial conditions, the air is filled with hard, gritty and abrasive dust. Its action might be likened to an abrasive compound mixed with a little oil. This dust proves very destructive to the chain and causes cutting into the joints, side cutting of the links and occasionally causes the pin to protrude. This latter occurrence is often spoken of as the "lengthening of the pin" by users who are not familiar with the cause.

The necessity of using a casing to retain the lubricant is equally obvious, and equally important. Silent-chain transmission requires lubrication. This can be accomplished by either periodic applications with a brush, or by the use of an oil bath into which the chain dips at all times. The latter is by far the better method and is a safeguard against neglect. If properly made of substantial material and with

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welded corners, the dustproof casing is oil tight as well. It is this dual combination that is most effective and efficient. As a very successful Ohio manufacturer puts it: "I would no more think of putting a silent-chain drive in my plant without a real casing than I would attempt to wear my Waltham watch without the casing provided for its works."

The third factor, which is equally as important as the other factors, is that of safety. Open transmission units of any kind need adequate guarding to prevent injury to hands or other parts of the body. Oilers in particular need protection because they frequently work from ladders or in places difficult of access, where a slip might be serious or even fatal. Also, there is the possibility of a chain or belt breaking and causing damage or injury. Adequate and proper safeguards prevent accidents by making them impossible. Also, it must be remembered that guards which will keep fingers out, will also prevent wrenches, oil cans, bolts, nuts or other loose pieces of metal, which might cause serious damage, from getting in between the chain and toothed wheels. Many state and industrial insurance company codes require such safeguarding. In such cases it is but little more effort to build an enclosing safeguard which will also exclude dust and facilitate lubrication. Properly-guarded silent chains are as safe as other means of power transmission.

Some mechanical engineers hold that a silent-chain drive can be operated without oil. Salesmen are frequently asked: "Can your silent chains operate without oil?" Certainly; but it is a principle of practical mechanics that any chain or other moving part will run better, last longer and require less attention, if it is operated with a proper supply of oil, in a dustproof, oil-retaining casing, than if it operates exposed and with little or no oil. All air contains some suspended dust, particles of which eventually settle on a chain, particularly if the chain is oily.

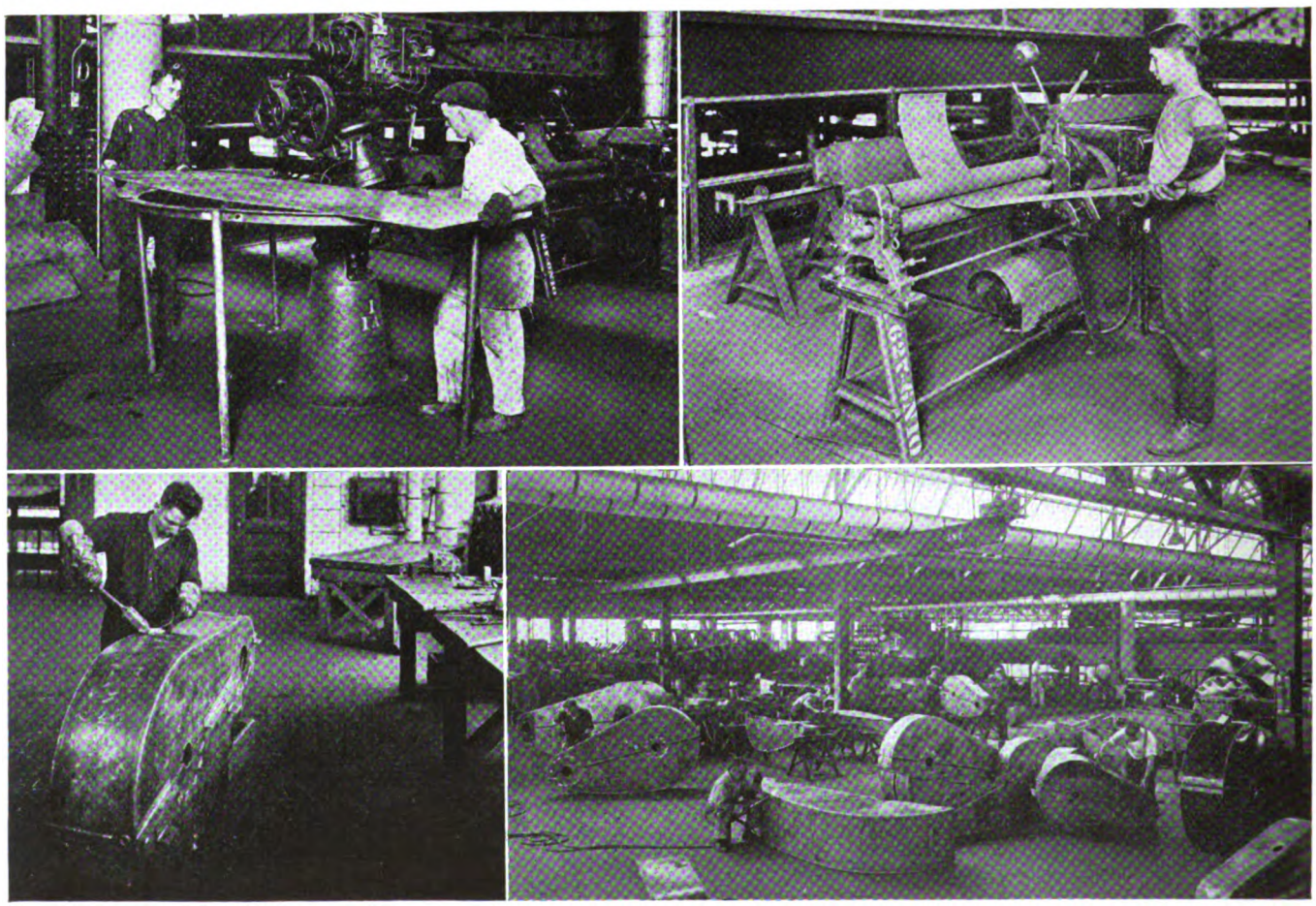
Silent chains, regardless of make, are composed of links and joints and usually operate at high speeds. Silent-chain drives are lubricated most satisfactorily when equipped with an oil-retaining and dust-tight casing, as assurance that such lubrication will be available at all times. Some of these casings and their method of construction are shown in the accompanying illustrations.

Ordinarily we recommend the use of Gargoyle drive-case oil for practically all types of installations. This is equivalent to 600-W oil. This grade of oil we have found satisfactory under practically any operating conditions of temperature or humidity. Dust-tight casings are relied upon to exclude moisture in damp surroundings and also abrasive material in dusty surroundings.

Where dustproof casings, made by the manufacturer of silent chains, are used the lubricant generally needs to be changed only about once a year. Under exceptional conditions

Four steps in the manufacture of a casing for a silent-chain drive in the Link-Belt Company shops.

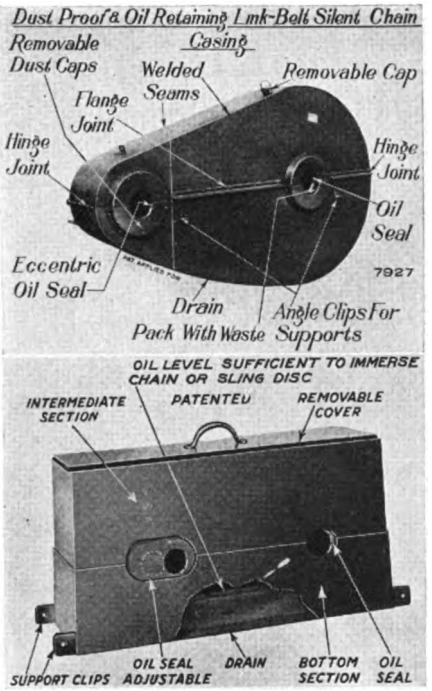
The first step is obviously to lay out the casing according to its size and shape. This is determined by the distance between the center line of the driving and driven shafts, by the diameter of the sprockets plus the thickness of the chain installed plus the additional amount of clearance required as given in the text. The machine at the upper left shows a method of trimming pieces of sheet steel to a curved line. In case a shop does not have a machine of this kind, the gage of metal used is not so heavy but that it can be trimmed in other ways. Practically every industrial shop doing any metal work whatever has bending rolls similar to those shown in the illustration in the upper right. Here the operator is curving the center half of a casing. The lower right illustration shows how the inlet or inspection flange is soldered on by hand. The view in the lower right is of a general arrangement of the shop and shows the construction of a number of large and medium-sized chain casings.



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it may be necessary to change the oil more frequently. Since the repair shop or sheet-metal shop of the average industrial plant does not have the equipment or the facilities for making casings as dustproof as does the manufacturer it is better to change the oil as frequently as every three months when home-made casings are installed. This is easily accomplished by draining off the old oil through the bottom drip plug and replenishing with new oil through the inspection slide or cap at the top. It is seldom necessary to use a light oil, such as gasoline, to wash out the casing. If it should be used it is not advisable to pour it on the chain as the light oil washes the lubricant out. Also, any light oil remaining in the casing dilutes the lubricant and so decreases its value.

The usual methods of lubrication are either by the splash system, in which the chain sprockets and chain are slightly submerged in oil, or by the use of a disc or sling, which throws the oil to the top of the casing from which it drips onto the chain. The former is usually used, but when the motor shaft is considerably lower than the driven shaft, the oil will pocket in the small end of the casing. In such cases, the disc type, as shown at the bottom of the page is used. It will be noted in this illustration that the disc automatically dips into the oil reservoir and throws the oil against a V-splash plate on the inside of the top. The oil drips down onto the chain and so provides a constantly uniform lubrication for as long time as the drive is in operation.



Two types of casings for use with silent-chains.

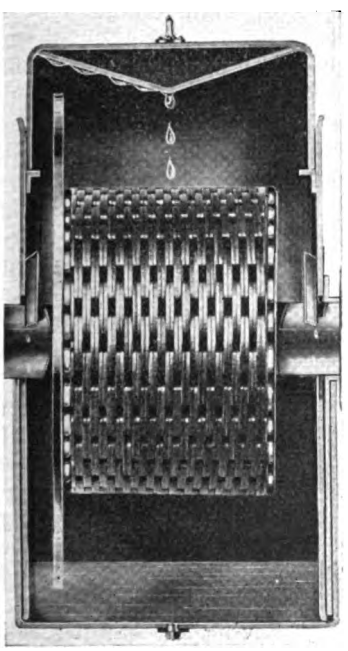
The general idea of how casings may be built up is shown from these two drawings and the cross-section view reproduced at the bottom of the page. By means of the adjustable oil seals, it is possible to take care of any slight vibration during operation. The method of lubrication by means of a sling disc is shown in the illustration at the bottom of the page. In other cases the chain dips into the lubricant during operation.

Casings, broadly speaking, are spoken of as either rigid or flexible according to the type of seal at the shaft openings. Those of the rigid type, as illustrated at the bottom of the page, are used mainly on fans, or where the load is smooth and there is little vibration. Casings of the flexible type, as shown at the top of the page, are more generally applied where there is a noticeable vibration. In either case these casings are equipped with an eccentric oil seal on the motor or driving ends, which permits of adjustment or motor take-up, without interfering with the casing supports, or losing its sealing feature around the driving or driven shafts.

These casings are of substantial material (about 12- or 14-gage, hot-rolled steel) with welded corners. It requires a rugged construction of this kind to successfully withstand the vibration and rough usage, and to prevent bulging and warping. There should be a greater insistance on the part of silent-chain users desiring casings, for those coverings which are ruggedly constructed. Only in case of necessity is it advisable to allow a local tinsmith or blacksmith to construct the casing, as he seldom has the ability, experience, or equipment to do the work properly. Also, it is difficult to get him to appreciate the importance of a good job. Poor casings have actually ruined an otherwise good chain drive installation.

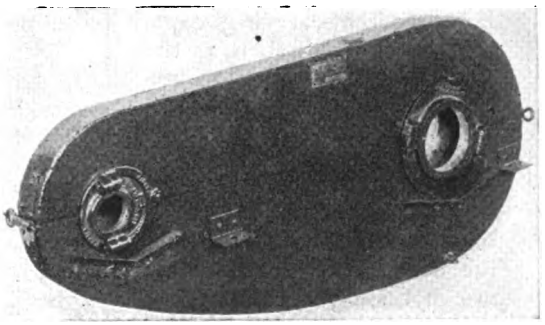
However, the practices used by the Link-Belt Company in the construction of casings may be of value to an industrial plant which prefers to make its own. Ordinarily, we recommend ½-in. clearance in width on each side of the sprockets and from 3-in. to 7-in. clearance at the ends of the sprockets with chains attached. This varies according to the size of the casing constructed. The casings are constructed by breaking and bending the sheets and welding the corners, edges and drip-plug at the bottom and the inspection opening on the top. Angle iron is not necessary to form substantial corners; good welding will make the corners strong enough. Casings are made split so that they may be installed or removed easily. This makes their construction easier as they can be welded on the inside as well as on the outside of the seams at the corners.

Recognition of silent-chain drives in power transmission in industrial plants has come strictly on merit. However, such recognition would be all the more definite and well defined if the users of silent chain will properly enclose and lubricate their installations. This simple expedient will enable this type of transmission to give the maximum in service with the minimum in required attention and expense.



An example of the rigid type of casing and one method of lubrication.

Rigid-type casings are commonly used on fans and where the drive operates with little vibration. This casing is provided with an eccentric oil seal on the motor or driving end which permits of adjustment or motor take-up without interfering with the casing-support, or without losing the sealing feature at the shaft. The illustration at the left shows the construction of a casing. In this disc or sling type of lubrication the disc dips into the oil and throws it onto the cone-shaped section in the top of the casing from which the oil drips down on to the chain.



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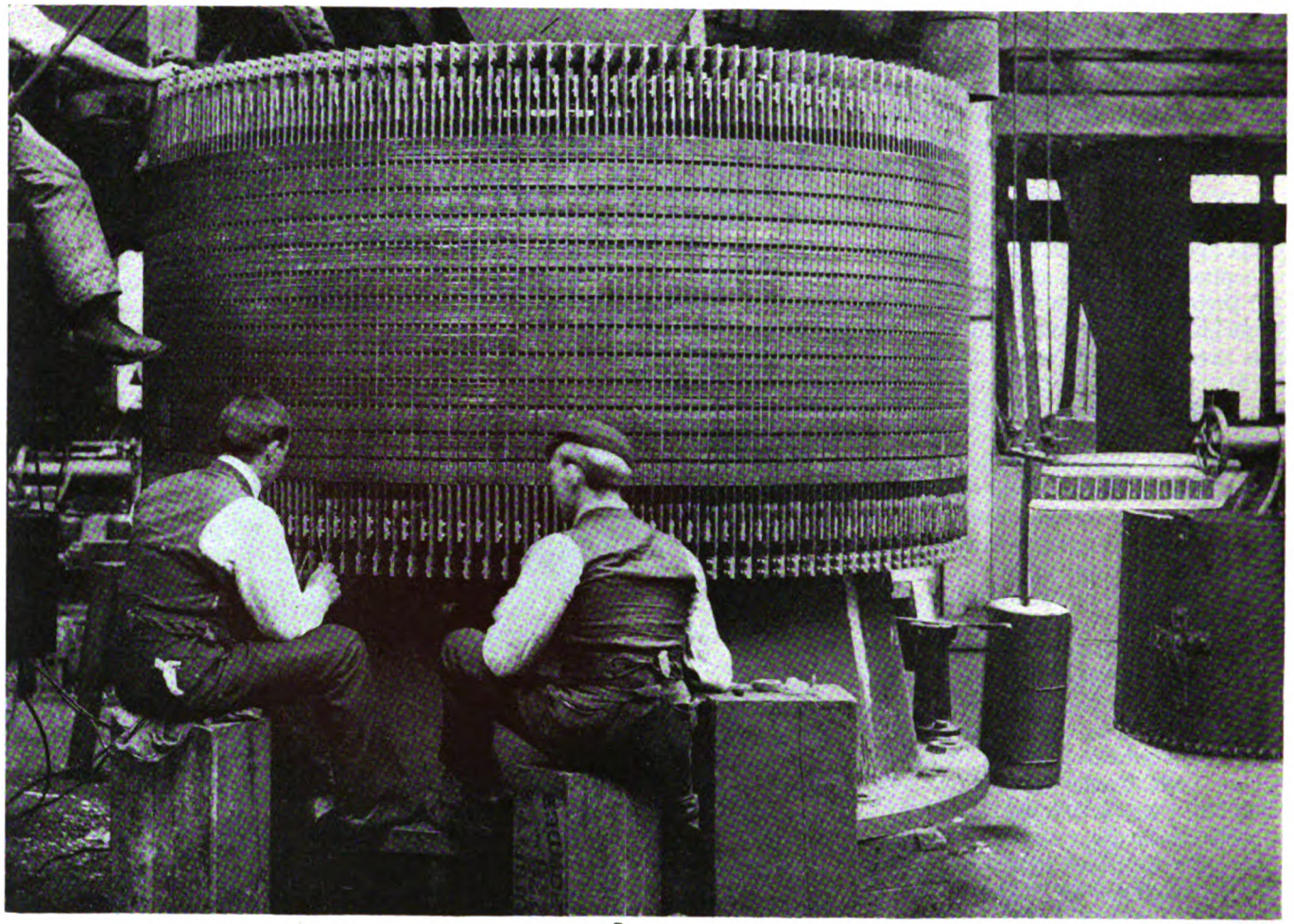


Fig. 1—This is a wave-wound, one-bar-per-slot winding used on the rotor of a large induction motor. Long and short bars are used alternately so as to secure two ranges for making the involute end connections. A close-up view of this winding is shown in Fig. 4.

Some of the Details About

Windings That Have One Bar Per Slot

Including the Manner of Making the End Connections and the Use of Long and Short Bars Together With Typical Winding Layouts

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WINDINGS having only one bar per slot are used principally in machines where large current-carrying capacity is required, such as the rotors of large induction motors and the stators of turbo-generators. This article, which is the second of a series of articles, discusses the uses of these windings in induction motors. A succeeding article will discuss their use in turbo-generators.

IN THE first article in this series on "Windings Having One Coil Per Slot," which appeared in the January, 1925, issue, it was pointed out that such windings are given that name because they have only one coil side in each slot. It was also developed that such a winding would of necessity be single-layer in the slot section, inasmuch as the slot can contain only one layer of coils. The coil ends, however, can be arranged in two or more layers. These windings are used principally on the older types of high-voltage motors and generators.

The previous article pointed out the various forms that one-coil-per-slot windings may take, such as the concentric chain, basket, diamond, and involute types of windings. The windings described, although having only one coil side per slot, had more than one conductor in each coil; that is, each coil consisted of more than one turn. We will now take up one-coil-per-slot windings in which a coil side consists of only one conductor; that is, a coil side would consist of one bar, and, therefore, each slot would contain only one bar. These windings are used principally in machines where heavy current-carrying capacity is required, such as the rotors of large induction motors and also in turbo-generators.

Windings having one bar per slot use long and short bars in the slot

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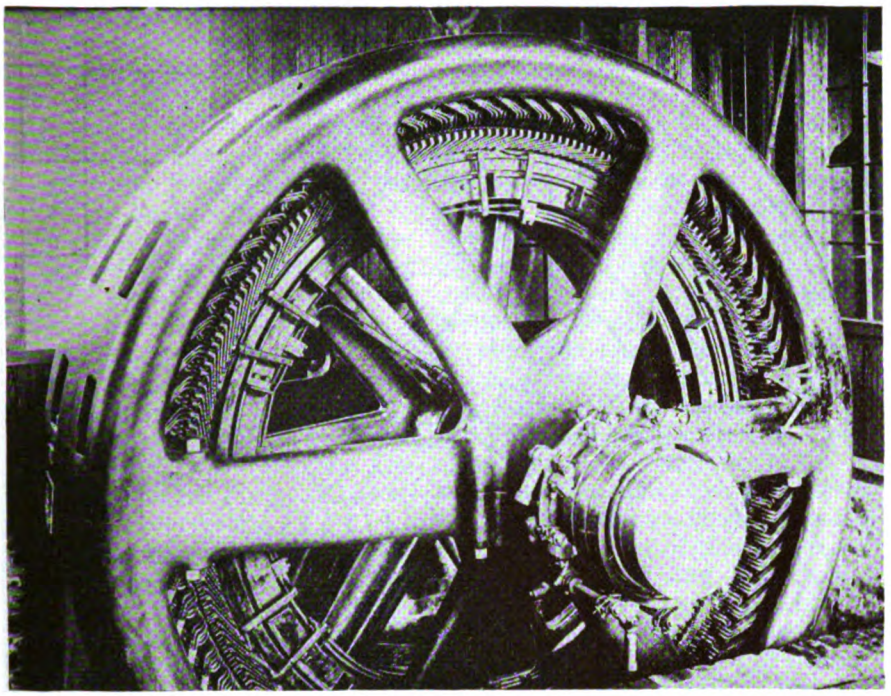


Fig. 2—Lap-wound, one-bar-per-slot windings are used on both the stator and rotor of this induction motor.
The end connections on both windings are of the involute type.

section and use the involute type of end connectors to form lap or wave windings, as required. Fig. 2 shows a machine having a one-bar-per-slot winding in both the stator and the rotor. In both cases, as can be seen by inspection of the illustration, involute-type end connections are used. Both the stator and the rotor of this machine are lap-wound.

In the preceding paragraph it was said that the bars in the slot section are of two lengths, a long bar and a short bar. This can be seen in Fig. 1. A close-up view of this same winding is shown in Fig. 4. Notice the use of the extra long bar for the connectors. Sometimes, instead of using the long and short bars, so as to obtain the space required for making the involute end connection, the bars are staggered, as shown in Fig. 3. In this case, the bars are of the same length, alternate bars being pushed to the right or to the left. Fig. 3 shows a wave winding.

A two-pole, two-phase motor having a one-bar-per-slot winding and using involute end connectors is shown in Fig. 10. In this winding the bars are all of the same length. The end connections are made in two ranges, being out on one side and in on the other. The winding diagram is shown in Fig. 11. It will be noticed that each phase is split into two concentric groups of coils. The winding diagram shows the complete connection for the A phase only. This winding has 120 slots, 60 slots per pole, and 30 slots per pole per phase, inasmuch as it is a two-pole, two-phase motor. The A phase is started at A_1, and connects to the front end of the bar in slot *1*. The winding then continues across the rear to slot *32*, across the front to the slot adjacent to slot *1*, that is, slot *120*, and so on through the coils of the concentric group. The concentric group ends in slot *46*. This group is connected to the second group by means of the jumper *XY*. The second concentric group starts at the front of slot *106*, then goes across the back to slot *47*, thence across the front to slot *105*, and so on through the group ending in slot *61*, which is the A_2 lead.

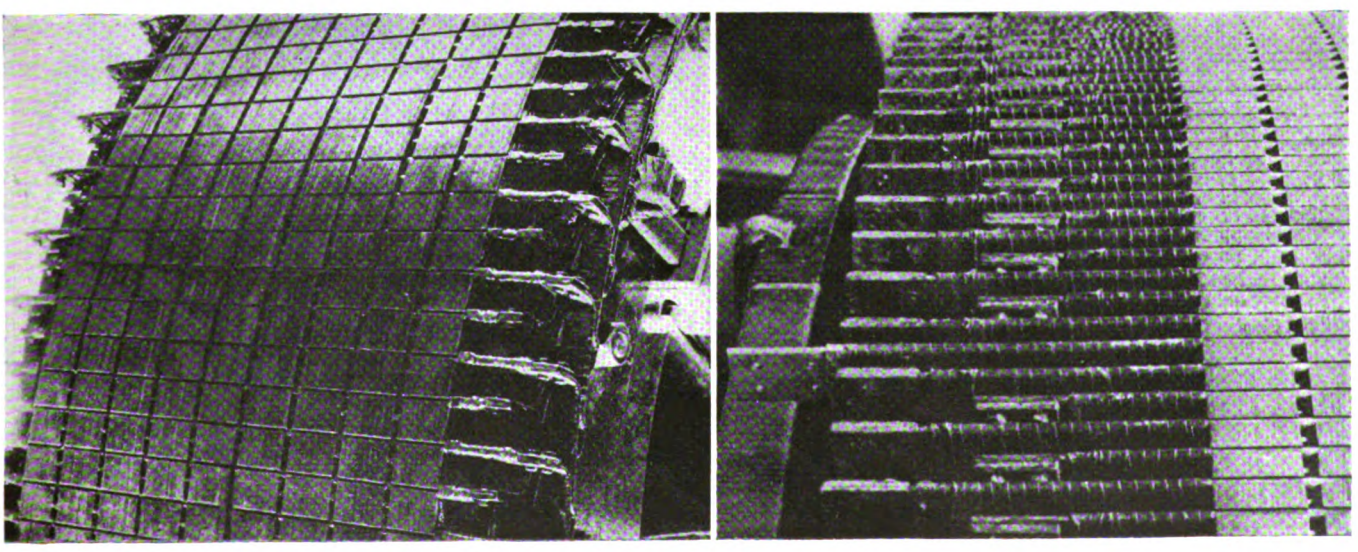
The starting lead for the B phase falls in slot *91*, and the finishing lead of the B phase falls in slot *31*.

In four articles on "Laying Out Wave Windings" in the September, October, November and December, 1924, issues of INDUSTRIAL ENGINEER, a number of rules were developed for use in laying out wave windings. These rules also apply to wave-wound, one-bar-per-slot windings.

Let us consider a few layouts of windings having one bar per slot. In Fig. 5 is shown a three-phase, series-star winding having four poles and three sections instead of the usual six sections.

In accordance with the rules re-

Figs. 3 and 4—Two ways of obtaining two ranges on one-bar-per-slot windings.
In Fig. 3 the bars are of the same length. As can be seen, the bars are staggered so that in one slot the bar extends farther on the right-hand side and in the next slot the bar extends farther to the left. This machine is wave-wound. In Fig. 4 two ranges are secured by using long and short bars alternately. Fig. 4 is a close-up view of the winding shown in Fig. 1.



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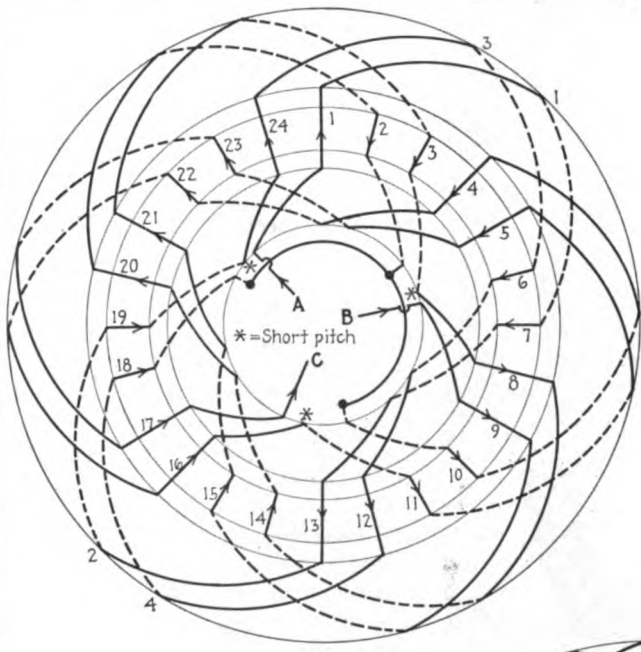


FIG. 5

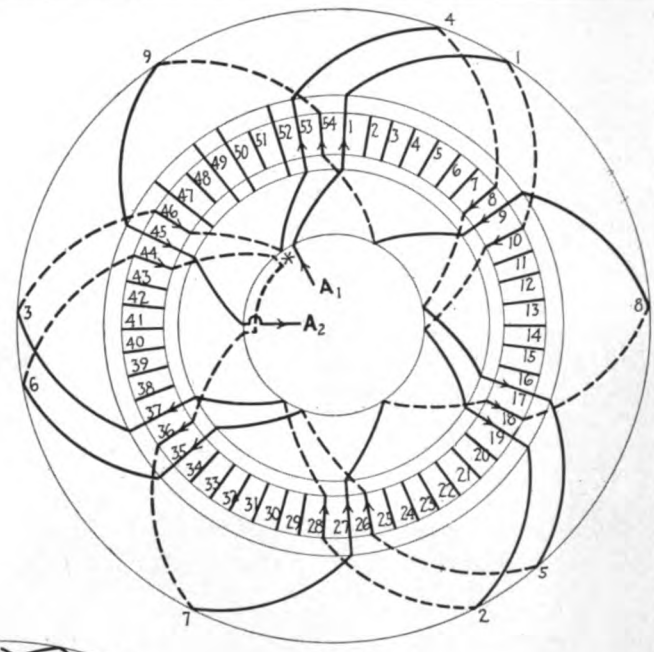


FIG. 6

Figs. 5 to 9—Here are typical wave-winding layouts for one-bar-per-slot windings.

In Fig. 5 is shown a three-phase winding having four poles, 24 slots, and three sections. Each section has four coils. This type of winding groups the end connections and has a minimum number of leads, inasmuch as no reversing jumpers are required. Fig. 6 shows the first phase of a three-phase, six-pole winding, having 54 slots and 27 coils. Each phase has two sections, the first section having six coils and the second section three coils. The complete diagram with the phases connected series-star is shown in Fig. 7. Fig. 8 shows the same winding arranged in three sections, or one section per phase, each section having nine coils. The start and finish of the phases are shown and also it can be seen that the phases start with long bars and finish on short bars. It will be noticed that the bars are grouped in sets of three, that is, three long bars are followed by three short bars and so on. This layout has fewer connections than the one shown in Fig. 7 as it eliminates the reversing jumpers. In Fig. 9 is shown the layout for a two-phase winding having 12 poles, 48 slots, and 24 coils. The bars are grouped in sets of four, each set being staggered somewhat in the manner shown in Fig. 3. There is only one section in each phase; consequently each section contains two series of six coils each.

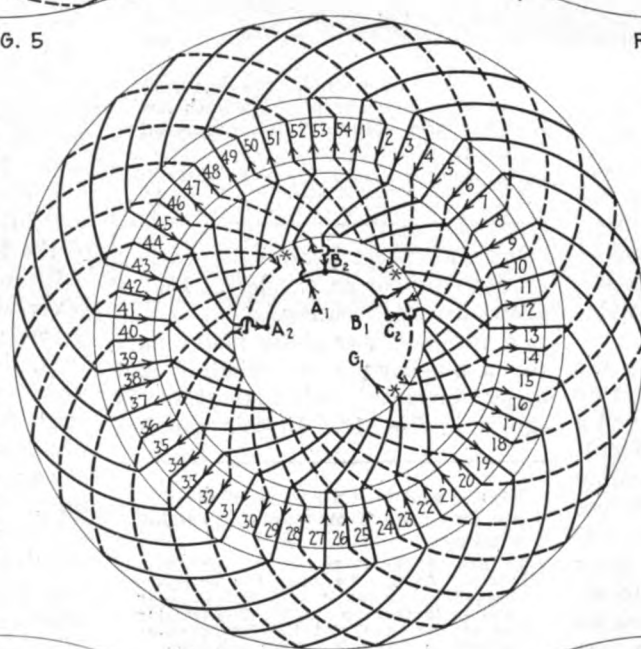


FIG. 7

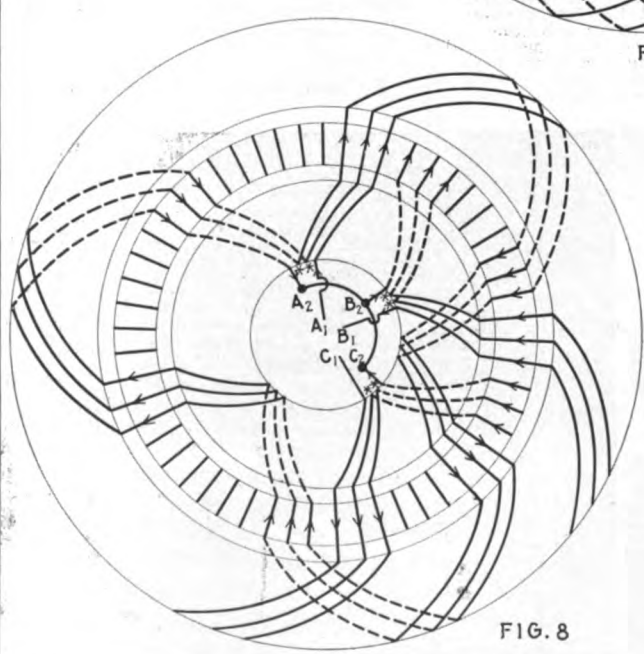


FIG. 8

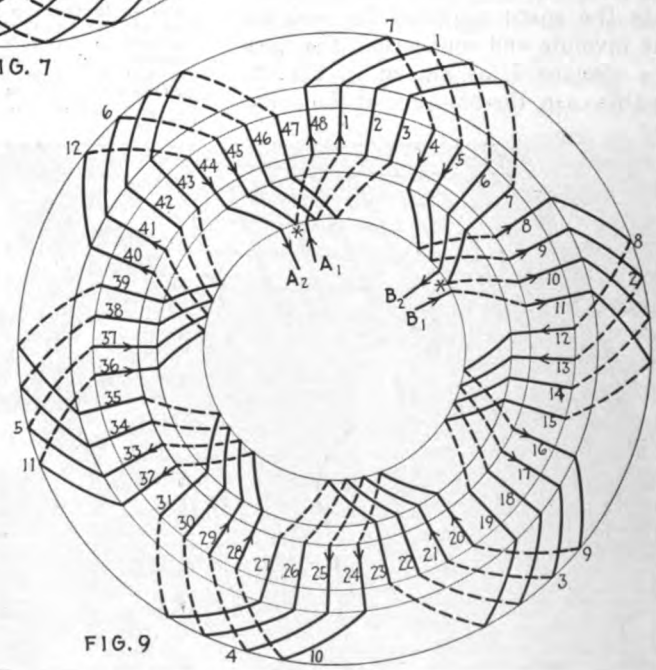


FIG. 9

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ferred to in the preceding paragraph the phases are started in slots *1*, *9* and *17*. Let us start the A phase in slot *1*.

The bar in slot *1* is connected across the back to the bar in slot *7*, and this bar is connected across the front to the bar in slot *13*, which in turn is connected across the back to the bar in slot *19*. The front end of the bar in slot *19* is connected to the front end of a bar in a slot which is a distance equal to a short pitch away, that is, in slot *24*. The winding then continues through the second series of coils in this section; it continues through slots *24*, *6*, *12* and *18*. The front end of the bar in slot *18* is connected to the star point.

It will be noticed that two lengths of bars are used in this winding. The winding starts on a long bar, then goes through a short bar, and continues alternately through a long bar and a short bar. This is done so as to provide two ranges in which the involute end connections may be made. The involute connectors overlap each other so that the top half of the connector is connected to the long bar and the bottom half of the connector is connected to the end of the short bar.

The overlapping of the involute end connectors can be seen in Fig. 3. In the diagram the top halves of the connectors are shown in full lines and the bottom half of the connectors is shown in dotted lines.

This style of winding groups the end connectors and has a minimum number of leads.

A three-phase, one-bar-per-slot, wave winding having six poles, 54 slots and 27 coils is shown in Fig. 6. Since there are 27 coils and three phases, there will be nine coils per phase. In this winding, there are two sections per phase; hence six coils are put in one section and three coils in the other. In Fig. 7 the first section is shown complete. As can be seen, the phase starts in slot *1* and continues through the first series of coils to slot *46*, where it is connected by a short pitch to the second series of coils starting in slot *53*. It continues through this series of three coils to slot *44*. This is the end of the first section of this phase. By means of a reversing jumper the front end of the bar in slot *44* is connected to the start of the second section; that is, the front end of the bar in slot *36*. The winding continues through the second section of three coils and ends in the bar in slot *45*, the front end of which is connected to the star point.

Long and short bars are used alternately in this winding in order to secure two ranges for making the end connections between bars.

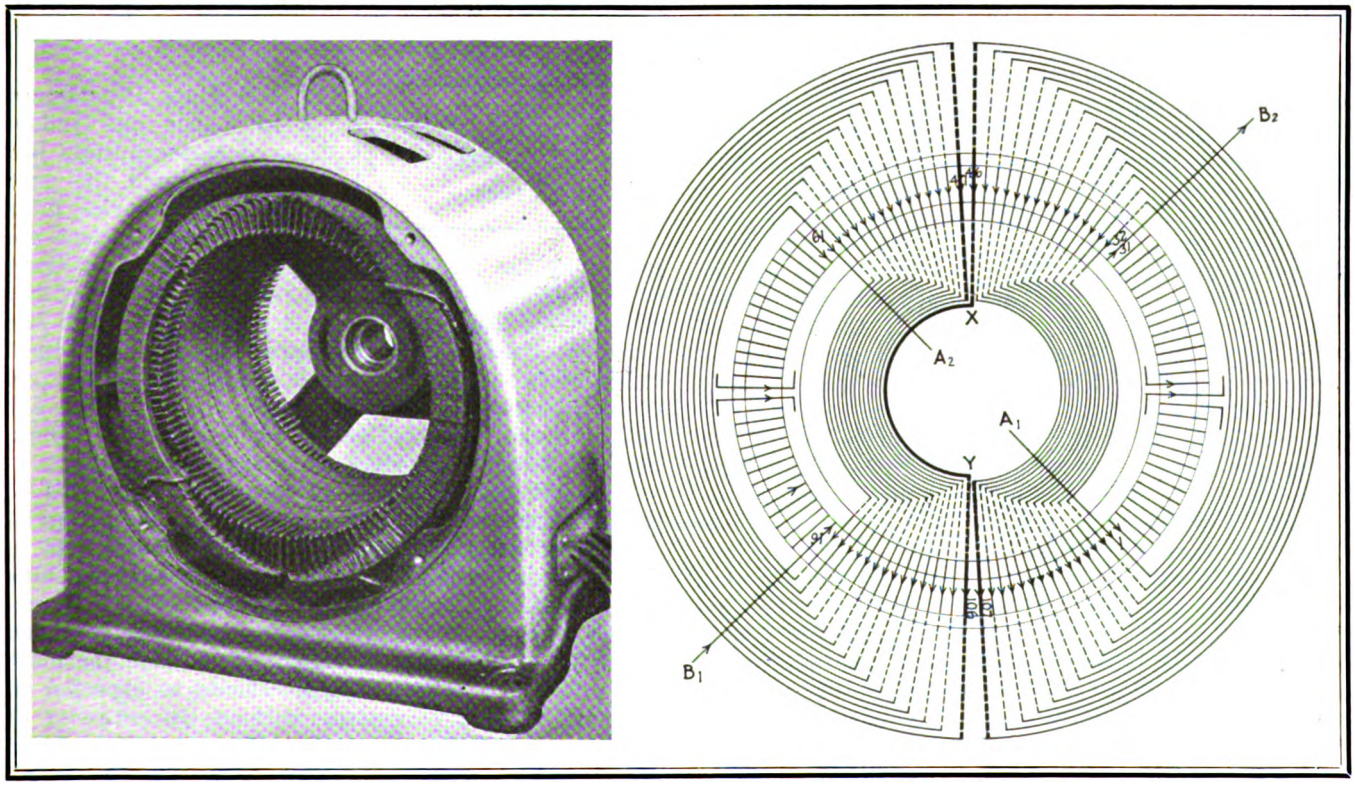
Fig. 7 shows the completed diagram for this winding. In connecting the phases a series-star connection has been used.

In Fig. 8, this same winding has been arranged with three sections instead of six, each section of which has nine coils. In this diagram the start and finish of the phases are shown, also it can be seen that the phases start with long bars and finish on short bars. Also it will be noticed that the bars are grouped in sets of three; that is, three long bars are followed by three short bars and so on. With this arrangement of this winding, no reversing jumpers are required.

A two-phase winding, using bars all of the same length, is shown in Fig. 9. This winding has 12 poles, 48 slots and 24 coils. It is wound in two sections. The bars are grouped in sets of four, each set being staggered somewhat in the manner that the bars are staggered in the machine shown in Fig. 3. As has been said, there are only two sections in this winding; that is, each phase is complete in one section. Each section of coils has two series, each series contains six coils.

In a succeeding issue the final article of this series on, "Windings Having One Coil Per Slot," will be given. The final article will treat of one-bar-per-slot windings as used in turbo-generators.

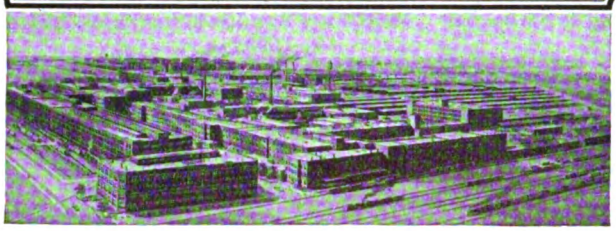
Figs. 10 and 11—This is a lap-wound stator using bar conductors arranged in four concentric groups. This machine is rated at 125 kva., 480 volts, 3,600 r.p.m., 60 cycle, two-phase and is made by the Burke Electric Co., of Erie, Pa. It has 120 slots, each of which contains only one bar. There are 60 slots per pole and 30 slots per pole per phase. In the wiring diagram shown in Fig. 11 is given the connection scheme of the winding.



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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E. GOODING A. J. WHITCOMB

Chicago, March, 1925

Who Pays for the Things You Waste?

AN ITEM in a recent issue of the *Studebaker Employees' Magazine* carries a thought on preventable plant leaks and wastes that we want to pass on to our readers. It read as follows:

Whether you waste water, oil, gas, air, or electricity by failing to shut off these supplies promptly when their use is unnecessary; whether you waste a pin, or a bar of steel, or an hour's time—you pay for it. Everything which Studebaker buys is charged into the prices of Studebaker cars. All costs, and therefore all losses and waste, must be absorbed in the selling prices of the cars.

Studebaker must continue to build a better car at a lower cost than other manufacturers if it is to compete successfully in the automobile business, **employ men** and **pay wages.** And, of course, the more Studebaker cars that are sold, the more continuous will be the employment of Studebaker men. Further, a concern which has less waste and loss to consider in its costs, **can afford to pay better wages.**

There is nothing new in these statements of fact. The wastes in the production and upkeep of every plant are included in the price of the product. But the idea inferred and expressed, that the employees of a factory pay for the wastes they create, in the long run, is worth thinking about. After all, the consuming public is made up of all of us, and most of us are workers making, selling, or in some other way identified with some product or service associated with that product, and we receive a wage or a salary based upon the money made through the efforts of all concerned. If, then, each and every one of us would realize that through failures to participate in the savings we could make, because we do not make them, a waste of our own time or the facilities furnished for doing our work comes out of our own pockets, we would watch these things more carefully. And, too, whenever we see a fellow worker unnecessarily wasteful or careless in such a way as to create preventable wastes, we would clearly see our duty to point out to him that not only our company but he himself is the loser. If he and all of us could get this idea and put it into practice, the millions of dollars annually wasted through carelessness and indifference would come back to us by eliminating the need for higher prices and help to reduce the existing costs of things we wear, eat and buy for comfort and pleasure.

In the final analysis, it is true that all of us pay for the wastes that we collectively create. Think this over and tell your men about it. It's a good thing to start an argument over at least, for it's an economic problem close to the heart and pocketbook of all of us who work for a living and want the highest return for our services.

The Repair Shop Is Not a Renewal-Parts Factory

THAT the majority of brush troubles are due to poor pigtail connections, was the opinion expressed by the field engineer of a large brush manufacturer. Brush troubles manifest themselves in many different ways and the usual conclusion is that something other than loose pigtails is causing the trouble.

One reason for pigtail trouble can be traced to the surprising amount of home-made brushes that are in use. Most reputable brush manufacturers have methods of making pigtail connections in such manner that they will not come loose. The average small repair shop does not.

Large users of carbon brushes state that there is no one grade of brush that can be universally applied to all of the plant equipment. For each type of equipment, there is a grade that will give maximum life with satisfactory performance. The average small repair shop is not in a position to experiment with the different grades of carbon to determine which will give the best results. In a plant where several grades of brushes are required, the plant repair shop cannot buy carbon in quantities or quality that will result in lasting economy so that for this reason alone the plant repair shop is not the place to start a brush factory. Although the price of carbon slabs is much less than the cost of finished brushes as supplied by reputable brush manufacturers, the cost of brushes should be measured in years of satisfactory life rather than in the first cost per brush.

In the last analysis, a repair shop is a place to repair broken equipment, and not to manufacture repair parts.

Only a Few Can See the Forest for the Trees

THE State Department of Labor and Industries of Massachusetts has recently adopted the code for lighting factories, mills and other work places approved by the American Engineering Standards Committee. This code follows the recommendations of the Illuminating Engineering Society and deals with the lighting of exits, and standards of minimum light intensity for workrooms, yards and storage spaces, to make working in these places safe and to reduce eye strain on close work. General requirements for shading light sources to reduce glare are also included.

It should not be necessary for state authorities to police common-sense lighting requirements in industrial works, for good lighting is just as effective a tool in the economical production of a product as any machine or device that is bought and used because it can be employed at a profit. The same application of common sense that causes efficient machinery to take the place of obsolete and inefficient types should be expected on the part of plant executives, without the necessity of pressure and police power applied by state legislation

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or inspections. Some time this fact will be realized, but as yet the credit for the economies in production quality and quantity resulting from lighting adequate for different working conditions cannot be claimed as an accomplishment of plant management or operation. It is and will continue to be a horrible example of not being able to see the forest for the trees, unless plant operators wake up and raise their lighting installations to the same standard of operation that they insist upon for other production methods, machines and tools.

Industrial Demands for Power

ADVANCE sheets of the first 175 pages of a report soon to be issued by the Giant Power Survey Board of the State of Pennsylvania give some very illuminating facts on production and utilization of power, which in that state exceeds 13 billion kilowatt-hours per year. That is more than is required by any two other states of this country.

It is pointed out in this report that 75 per cent of every dollar of wealth produced in Pennsylvania is from manufacturing and that it has twice the volume of installed horsepower in industry of any other state. In 1904 the energy used was 4,200 kw.-hr. per worker. Today it is more than 8,500 kw.-hr. per worker, an increase of more than 100 per cent, with a 41 per cent increase in the number of workers during the past 20 years. If the use of power continues at the present rate, the Board predicts that by 1950 the industries of Pennsylvania will require double the installed horsepower that exists today, or more than 13,000,000 hp.

These figures are a good index to the growth of manufacturing in this country and the extent to which electrical drives and other equipment that depends upon electrical energy for its operation are being installed. Motor applications and the mechanical devices that are employed in this connection offer a wider field for specialized attention than ever before, because the range of drives is greater and the variety of operating requirements is continually increasing as industrial processes are improved and changed to bring about greater production economies.

If Horace Greeley were alive his advice most probably would be, "Young man specialize in electrical and mechanical drive engineering."

How Safety Helps Machinery As Well As Men

ORIGINALLY industrial safety devices were installed to reduce the appalling number of serious injuries, maimings and deaths which were considered by some as inseparably linked with production. The result was more than expected. Savings of life and of limb and of cost of compensation have exceeded the cost of protection. Safety work has paid for itself.

There is still another class of industrial safety work which also pays for itself. This deals with the protection of machinery, motors and other production equipment. Incidentally both types of safety work are closely related. A guard on a chain drive, for example, which keeps fingers or hands out also prevents wrenches, bolts, nuts, oil cans or practically any other metal parts from getting in and damaging the chains or teeth in the sprockets. Similarly, where oil or grease cups are located in points difficult or dangerous of access, the oiler can hardly be blamed for "overlooking" them occasionally. Grease cups or pipes extending out through a guard leave no excuse for neglect—also no likelihood of injury. Here the protection to the man is incidentally good protection to the machine because neglect in lubrication is one of the common causes of mechanical breakdowns.

Other advantages from the standpoint of mechanical safety as applied at the Battle Creek, Mich., plant of the Postum Cereal Co., are taken up in the article beginning on page 118 in this issue. Here the plant is in continuous operation and breakdowns or interruptions would be serious. When a machine fails and goes to the repair shop "hospital," production stops and in some departments the product is a total loss. For this reason every precaution possible is taken to see that no breakdowns occur and that injuries to workmen are avoided.

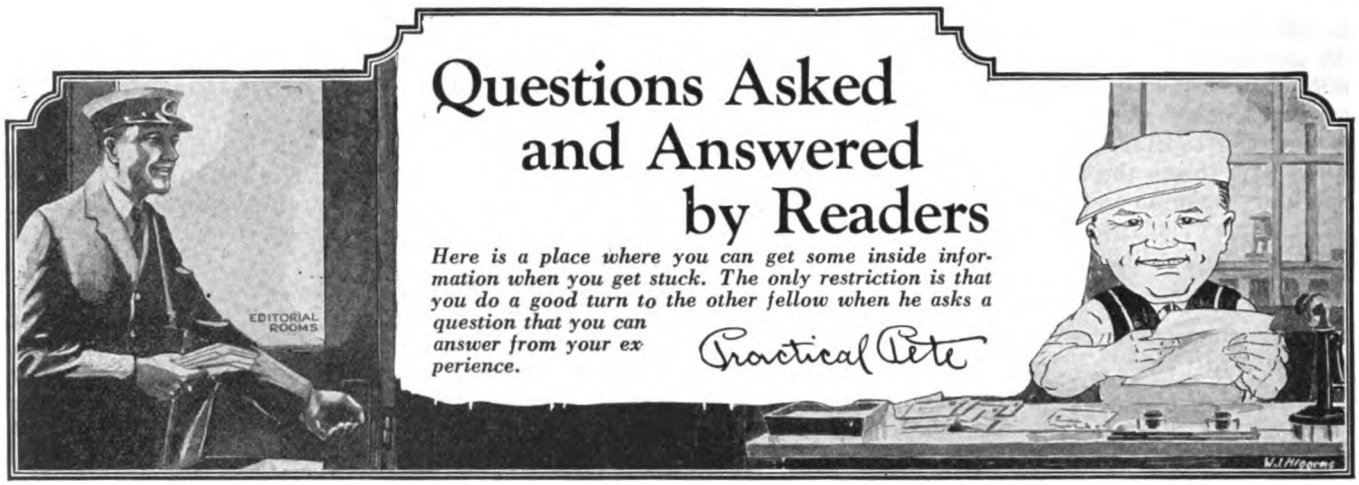
Overfeeding and Starving Storage Batteries

MOST of us who drive automobiles have an opportunity to learn a lot about storage batteries that will be useful in obtaining the maximum service from them when used in plant work. One thing that cuts down the useful life of battery plates in any service is regular overcharging or charging at too high a rate. Excessive overcharging will tend to buckle the plates in the same way as violent discharging, and will be indicated by the battery plates and connections heating up. Excessive heat causes unequal expansion of the active material and will bend the grids out of shape and start trouble that can only be remedied by extensive repairs through replacement of the damaged plates. Excessive heat also hastens the chemical decomposition of separators which results in short-circuits.

In the majority of cases when short life of batteries is experienced in electric industrial trucks the trouble can be traced to careless handling of the battery charging and to abuse while in operation through allowing the batteries to stand in a discharged condition or failure to keep the plates covered with water, producing a condition of sulphation that requires expert treatment when the battery is placed on charge. Plates that are partially sulphated can be saved in many cases by simply charging at a low rate for three or four days and not allowing the temperature of the battery to exceed 100 deg. F. But if such a battery is placed on charge at a high rate, the plates will get hot because only those parts not covered by lead sulphate carry the current, and besides the cells will begin to gas excessively and cause shedding of the active material. The battery will then be quickly ruined.

The lead storage battery as now constructed is about the sturdiest piece of electrical apparatus made, when given a chance to work under favorable conditions. When unusual trouble is experienced and batteries wear out quickly the causes can usually be found and removed by regular inspections by an experienced battery man and a little more care and attention when they are charged. Charging a battery is like feeding a horse—if you overfeed him he founders and if you starve him he dies.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Thickness of Mica Required for Slot Insulation—Will some reader please tell me what thickness of mica should be used to replace one layer of 0.007- or 0.010-in. varnished cambric and one layer of 0.007- or 0.010-in. fishpaper for slot insulation?
St. Louis, Mo. L. C. R.

• • • •

Trouble With Rewound Automobile Generators—I have been rewinding some automobile generators, but in spite of the fact that I always check up the old winding and make the new one as nearly like it as possible I sometimes have trouble in getting the proper amperage out of the generator. The voltage will be up to normal, six volts, but the charging rate is too low. I wish some reader who has had experience in such work would give me some suggestions as to where the trouble may be.
Bathurst, N. B., Can. H. J. M.

• • • •

Connecting Three-Phase Power Factor Meter—I should like to obtain the following information from some of the readers of INDUSTRIAL ENGINEER. (1) How may a three-phase power factor meter of General Electric make, be connected up for correct operation on either leading or lagging current when all of the polarity marks have been obliterated? (2) How may the circuits of the above meter be tested for continuity and zero setting of the pointer when it has been moved on the revolving shaft which supports it? (3) What would cause a shunt generator driven by an induction motor to build up slowly at the commutator and develop destructive arcing at the brushes after the load has been removed? What would be the remedy for such a condition? The armature is a single, parallel winding.
Saskatoon, Sask., Can. F. N. G.

• • • •

Arrangement of Motor Testing Panel—We have recently fitted out an electrical repair shop in our mill and have all of the necessary equipment except a testing panel for motors. Voltages of 110, 220, 440 and 2,200, three-phase, are available and I have a blank panel measuring 2 ft. by 3 ft. which I should like to use, if possible. I shall appreciate it if some reader will tell me how to lay this out in the most convenient fashion for testing a.c. and d.c. motors before and after rewinding, including high-voltage tests between coils and between coils and ground, and running tests.
Cloquet, Minn. E. S. B.

• • • •

Using Vacuum Pump as Air Compressor—I have a Wahl vacuum pump, size 4 in. by 2½ in., with ¾-in. inlet and outlet, which I wish to use as an air compressor. The pressure in the air tank need not go over 125 lb. per sq. in. Will someone please tell me, (1) What size motor would be required to drive this pump at 275 r. p. m. (2) Will it be necessary to make provision for cooling this pump artificially, by means of air fins or water, in order to keep the temperature down to a safe limit? (3) How do you figure the cubic inches of air compressed per stroke?
Dallas, Tex. R. E. L.

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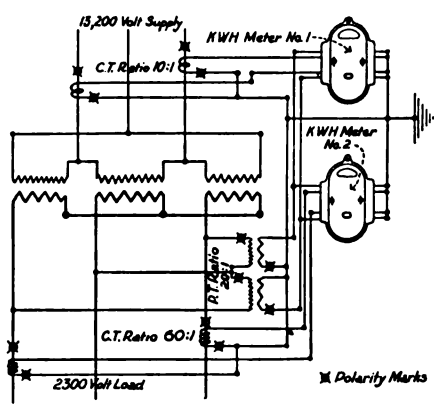
How Long Will It Take to Erect These Towers?—I shall appreciate it very much if some of the readers of INDUSTRIAL ENGINEER can give me the amount of time in man-hours required to erect five steel transmission towers, 9 ft. by 15 ft. at the base and 60 ft. high. I should also like to know the time required to string three No. 3/0 stranded copper cables and one overhead ground wire a distance of 2,000 ft.
Appleton, Wis. M. P.

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How to Use Megger for Testing Insulation of Motors—I wish some reader would give me a few suggestions on the proper method of using a megger for testing the insulation resistance of motors. I should also like to know what is considered a satisfactory reading when testing 110/550 volt, a. c. and d. c. motors ranging from 5 hp. to 50 hp.
Latrobe, Pa. J. K. W.

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Will These Watt-hour Meters Read Alike?—The diagram shows a proposed method of connecting watt-hour meters on the primary and secondary sides of a bank of transformers connected delta-star. As shown, the meter measuring the high-tension power receives its current from current transformers in the lines supplying the delta-connected primary, while the potential supplied is the low-tension line voltage. The low-tension watt-hour meter is connected in the usual manner. I should like to know if this connection for No. 1 meter will work satisfactorily. Also, if we disregard the copper and iron losses in the transformers will there be any difference in the records of the two meters at unity power factor, and at 85 per cent, 70 per cent and 45 per cent lagging power factor, assuming that the load is always balanced?
Longview, Wash. J. C. R. C.



Answers Received To Questions Asked

Commutator Trouble with Interpole Motor—I have a 15-kw., six-pole, compound-wound, interpole exciter, for a synchronous motor, that has three black and somewhat flat spots at equal intervals around the commutator. This machine has a lap winding and the mica is not undercut. There is always some sparking at the brushes. If I shift the brushes, the black spots move in the direction the brushes are shifted. I lifted the leads from their risers at each spot and tested for open circuits with a test lamp, but everything seemed to be O. K. Will some reader please suggest a cause and the remedy for this trouble?
St. Croix Falls, Wis. K. A.

In reply to the question by K. A. in the November issue, I would suggest that he carefully test the armature for high-resistance connections or open circuits, as the symptoms he describes point to this form of trouble. It might also be that there is a high-resistance brush contact at the particular bars that seem to blacken. It would thus be well for him to see that the brushes make good contact with the bars. Probably it would be advisable to undercut the mica very slightly. I would suggest, as a further precaution, that he check up the clearance between the armature and pole faces, to see that the clearance is equal at all poles.
Muncie, Ind. GEORGE CROPPER.

* * * *

Referring to the question by K. A. in the November issue, I would say that, if these blackened "flats" occurred after the generator had been operating successfully for some time, the symptoms described would indicate trouble in the equalizer connection. Apparently K. A. has made sure the trouble is not due to defective soldering of the armature leads to the commutator bars. His next move should be to examine carefully the taps from the armature winding to the equalizer rings. I take it for granted that this exciter is equalized with cross-connectors, as this is standard practice with lap-wound, multi-polar machines such as he describes. If such is the case, and the machine has behaved this way since it was first put in operation, the trouble is probably due to the use of too few equalizers. These equalizing rings are mounted either at the commutator end or at the rear end of the armature; in one case they are tapped to the risers of the commutator bars, and in the

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other case to the armature conductors themselves. There should be as many equalizers as there can be made room for; at least, one for each armature slot. These equalizers connect together all points in the armature winding which are at the same potential, thus preventing a heavy flow of current through the various armature paths. When there are not enough equalizers, or when their resistance is increased by defective joints, the heavy currents flowing internally produce just about the same effect as K. A. describes.

Honesdale, Pa. J. M. WALSH.

* * * *

In the November issue of INDUSTRIAL ENGINEER, K. A. reports three black spots on his exciter commutator and has tested for open circuits and found none. Black spots as described are caused by short-circuited coils as well as by open-circuited coils. Possibly this is the trouble in the present case.

ROGER F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

In answer to K. A's. question in the November issue, I believe the poor commutation on his 15-kw. six-pole exciter is due to one of several faults, or a combination of them.

He states that the commutator is not undercut; therefore, the first cause may be high mica. A flat is often started by one high mica segment lifting the brushes from the commutator bars under one brush arm, thereby overloading the other two brush arms of like polarity and burning the commutator segments at these points also. In this way, three flats are started 120 deg. apart and the blackened areas gradually grow wider.

The remedy for this is to turn the commutator in a lathe, taking pains to see the flats are removed and then undercut the mica about $\frac{1}{16}$ in.

Another cause would be one or more high-resistance connections at the risers. A high-resistance contact can be located by testing the armature from bar to bar by the drop-of-potential method. When located, resoldering will correct this trouble.

Again, the brushes may not be properly spaced and may not be set on the neutral point. To correct the spacing, count the bars between brushes and shift individual brush arms until there are the same number of commutator bars between the brushes, counting from toe to toe of all brushes.

To check the neutral, the kick method is very accurate, if properly used. It should be carried out as follows: Lift all brushes from the commutator and insert two brushes (one in a positive and one in a negative brush arm). These brushes should be sanded down so as to bridge only one mica segment in the center of the brush holder. Now separately excite the shunt field with approximately 50 per cent of the exciter's rated voltage, with a test switch between the exciter and the source. Connect a low-reading d. c. voltmeter, say 0 to 2 volts, across the two special brushes and close the test switch; then slowly open it again while watching the voltmeter. If a deflection of the voltmeter pointer is noticed, the brushes should be shifted until the least deflection is obtained. The brushes are then set on neutral, which should be correct for a machine with interpoles.

Another condition which would tend to cause poor commutation is worn bearings. This would allow the armature to vibrate, causing sparking at the brushes. New bearings would correct this.

The armature may be out of balance. This will also cause sparking and wear in the bearings. Re-balance the armature in this case.

K. A's. trouble may be due to one or more of the foregoing conditions, and I hope this information will be of some benefit to him.

Columbus, Ohio. G. B. H.

* * * *

Referring to K. A.'s question in the November issue, about a year ago I had a similar experience with a 100-kw., 1200-r.p.m., 6-pole, compound-wound, interpole, motor-driven generator used for exciting purposes in one of our generating plants. Carbon brushes somewhat abrasive in character had been used on the commutator of this exciter, with the result that it was badly worn in ridges. In an endeavor to smooth down the commutator, a commutator stone was used, but because of unskilled handling a flat spot was made and the commutator was ground slightly out of round, or eccentric.

When placed in service considerable sparking was immediately noticed and when shut down after a short run, three black spots were in evidence at three equidistant points on the commutator. One of the black spots was on the flat spot previously noted. As the machine was urgently needed it was run in this condition for some time, but as the sparking gradually grew worse, the armature was finally removed and the commutator turned down with lathe tools.

A suitable non-abrasive brush had meanwhile been recommended for this unit by a reliable brush manufacturer and when a set of these were mounted after turning down the commutator, the results were excellent. The unit has now been operating for over a year without the slightest sign of sparking and with that healthy commutator color that indicates good condition of brushes and commutator. FREDERICK KRUG.

San Juan, Porto Rico.

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Referring to K. A.'s question in the November issue, I would suggest that you tap the bars lightly all around the commutator and note whether they move or have a tendency to vibrate when struck. If the commutator shows any signs of being loose, take the armature out, heat the commutator thoroughly with a blow torch and try to tighten the retaining nut at the end. After the commutator has cooled off tap it again with hammer and see if it is now tight. If it is not, take off the retaining nut, remove the front V-ring and put on 0.010 in. or 0.020 in. of molding mica. Now put the V-ring back in the commutator and tighten it as much as you can with the retaining nut. Then heat the commutator again as above and try to tighten it while it is hot, and again after it has cooled off. Then if it sounds solid, put it in a lathe and turn it down smooth.

I would also advise you to undercut this commutator about 1/32 in., not more, for if it is undercut too deeply carbon and copper dust will accumulate between the bars and sooner or later cause a short-circuit.

It is also possible that the brush holders are now set at a different angle or in a different position than they were originally. To check up the neutral point connect a millivoltmeter, or a low-reading voltmeter, across any two adjacent brush holders with the armature circuit open and pass direct current through the field. It is advisable to place the d. c. switch close to the motor so that you can open or close the switch quickly. As you make and break the circuit through the field there will be a deflection on the meter. Now, moving the brushes back and forth you will find a point where there is no deflection; this is the neutral point, on which the brushes should be set.

It is also possible that equalizers should be put in this armature, as these will prevent circulating current caused by unequal air gaps, worn bearings, or by one field pole being weaker than another. If you decide to put in equalizers you will probably find sufficient room back of the commutator, on an armature of this size. Take a small chisel and cut slots in all of the risers on which you want to put equalizer connections. The wire used for the equalizers should be not less than one-half the circ. mil area of the wire in the armature. On page 599 of the December, 1924, issue of INDUSTRIAL ENGINEER, A. C. Roe explained in detail how to calculate the number and position of the equalizer connections.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

Motor-Generator Set for Testing Small Single-Phase and Three-Phase Motors—Will some reader please tell me what capacity motor-generator set (d.c. motor—a.c. generator), method of drive and style of generator I could use for testing single-phase and three-phase, 60-cycle, 220-volt motors up to 1 hp. rating? Is it possible to change over from 25 cycles to 60 cycles, from 110 to 220 volts and from single phase to three phase, or the reverse, just by means of throwover switches? What changes would have to be made in the motor and generator in order to secure 25-cycle current? What capacity would be obtained from a 60-cycle set delivering 25-cycle current?

Chicago, Ill. E. J.

Referring to the question by E. J. in the November issue, the simplest kind of set to operate, if all testing is done at 60 cycles, 220 volts, would be one having a single-phase rating, for the a. c. generator, of 1 hp. per phase or 3 hp. on three-phase. This would have a rating of about 2.25 kva. at 100 per cent power factor, as a three-phase machine, and would be of sufficient capacity unless testing is carried on continuously, in which case a machine of 3 kva. would have ample capacity.

To test 25- and 60-cycle motors, it would be best to have either two separate motor-generator sets, one for each frequency, or one motor driving two generators. If it is desired to test a 25-cycle motor on a 60-cycle generator it would be necessary to reduce the generator speed to 25/60 of the 60-cycle speed and increase the field excitation to keep up the voltage. This could probably not be done with a commercial generator. On the other hand, if the generator operates normally at 25 cycles, the speed would

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have to be increased to 60/25 of the 25-cycle speed and the excitation decreased to give the correct voltage. It would probably not be possible to obtain a commercial machine which would operate through this speed range.

Generators can be purchased with a single stator and two separate revolving fields, one for 25 cycles and one for 60 cycles. Machines of this type are in use in laboratories where the delay involved in changing the fields is not of serious moment.

It should be remembered that only certain speed-and-pole combinations can be used in sets for a combination of 25- and 60-cycle operation. The most usual combination is a speed of 300 r. p. m., which would require a ten-pole machine for the 25-cycle unit, and a twenty-four-pole machine for the 60-cycle unit. With machines of such low capacity it would probably not be possible to obtain these combinations and it would therefore seem best to purchase separate sets having commercial speeds, rather than to combine all of these features in one machine or set.

A change of voltage from 110 to 220 volts can readily be made with a throwover switch, but from the foregoing it may be noted that a change in frequency is not so easily obtained.

A 60-cycle machine operated at 25 cycles would, providing the voltage is kept up by an increase of field excitation, have the same capacity. But the field would have to be especially designed for such service. For a commercial machine it would be necessary to limit the field current to a definite maximum. This would, of course, give a lower voltage at the reduced speed and reduced capacity in proportion to the reduced voltage, the exact value being dependent upon the design of the machine. In addition, it would probably be necessary to provide transformers to raise the voltage to 220 volts if required.

Summing up the whole matter, I believe it would be best to purchase separate sets to operate at commercial speeds and not attempt to obtain a very special outfit which would of necessity be higher in cost.

C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp.,
New York, N. Y.

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Referring to the question by E. J. in the November issue, the simplest outfit, and no doubt the cheapest, would be a motor-generator set driven by a variable-speed d. c. motor. This set should be 5-kva. capacity, or thereabouts.

The generator should be direct connected to a d. c. motor of suitable voltage. The speed of the motor should be 1,200 r. p. m. or 1,800 r. p. m. at full speed; 1,200 r. p. m. will give 60-cycle current with a six-pole generator and 1,800 r. p. m. will give 60-cycle with a four-pole generator. The generator should be of the stationary-field type, rated at 220 volts, 60 cycle, three phase. Now, 110 volts can be obtained by weakening the field of the generator through a properly designed rheostat. Single-phase current can be obtained from any two leads from the generator.

For 25 cycles the generator speed will have to be reduced to 500 or 750 r. p. m., depending on whether it is a four-pole or six-pole machine. Through the use of a suitable speed regulating rheostat on the drive motor, this speed can be obtained. By regulating the field strength of the generator, either 110 or 220 volts, single phase or three phase, can be obtained at 25 or 60 cycles.

I would advise the use of a 5-kva. generator direct connected to a 5-hp. d. c. motor so that the outfit will have sufficient capacity at 25 cycles, as the capacity at 60 cycles will be 240 per cent greater than at 25 cycles. The only switches necessary will be a three-pole switch for the three-phase current. A two-pole switch for the single-phase current would be convenient if E. J. desires to test a single-phase and a three-phase motor at the same time.

Donnacona, Que., Can. LEE F. DANN.

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Design of a Growler for Testing Armatures—I wish some of the readers of INDUSTRIAL ENGINEER would tell me how many turns and what size wire to put on a laminated core in order to make a growler for testing armatures up to 50 hp. in size. This core is 8½ in. x 4 in. x 4 in., and has a 1¼-in. slot cut into it. If necessary I could make the core longer. Alternating current of 110 or 220 volts is available for operating the growler.

Canton, Ohio. R. M.

In answer to the inquiry of R. M. in a recent issue for information on the construction of a growler, I wish to submit the accompanying diagram and information: The smaller growler will take small electric drill or fan motor armatures from 1¾ in. in diameter up to about 4 in. in diameter. As will be seen from the drawing, it is built up of laminations stacked to a thickness of 3¼ in. and riveted to 4 pieces of angle iron by means of which the laminated core is attached to the wood base. For use on 110-volt alternating current the coil is wound with 150 turns of No. 13 B. & S. gauge d. c. c. wire. The push switch shown at the right serves for turning the current on or off.

The larger growler is 5½ in. high, 8 in. thick and has a radius of about 9 in. For 110 volts the coil is wound with 45 turns of No. 5 B. & S. gauge d. c. c. wire. This growler has given satisfactory results on armatures up to 30 in. in diameter.

These two growlers cover a wide range of armature diameters and will usually be found sufficient for most requirements. Care should be taken not to apply the current until the armature to be tested is in place on the growler and not to remove the armature before the current is turned off, so as to prevent an increase of current through the growler winding, which might cause it to burn out.

To wind these growlers for use on 220-volt alternating current, double the number of turns and use wire of half the size employed when the growlers are used on 110 volts.

Cleveland, Ohio. P. JUSTUS.

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Starting Trouble with Motor-Generator Set—In starting a synchronous motor-generator set the motor field is first short-circuited by the double-pole, double-throw, quick-break switch, which is provided with a short-circuiting resistance contact that closes just before the switch is opened from one direction and opens just before the switch is closed in the other position. The motor is started and comes up to speed on 2,000 volts; the field switch is then thrown to obtain excitation from the 250-volt bus. The running voltage of 6,600 volts is then applied. When the field switch is thrown from starting to running positions there is a bad flash between the hinge clips and the short-circuiting resistance jaw. What is the cause of this flash and how may it be avoided?

Pittsburgh, D. W. B.

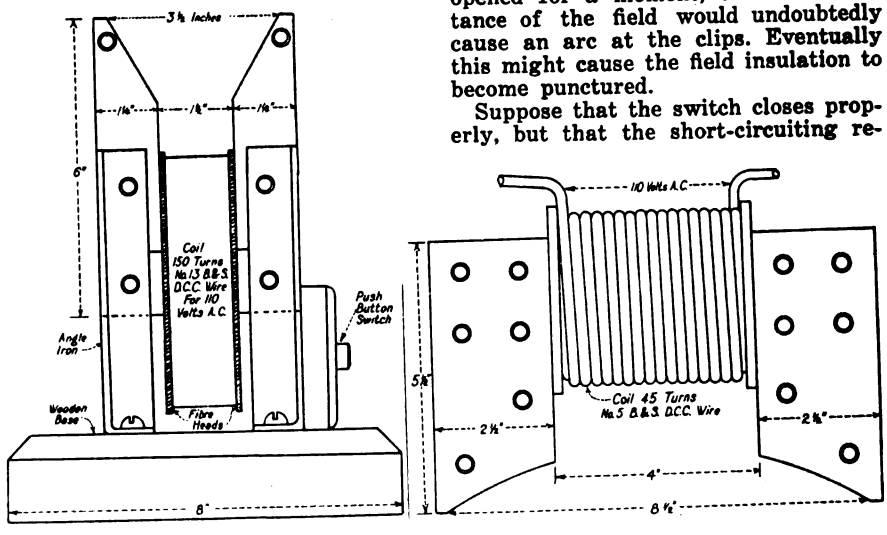
In answer to D. W. B.'s question in the November issue, I believe he will find that his trouble is due to the short-circuiting resistance being removed from the field circuit before the field excitation is applied. I do not quite understand the statement in which he says, "the double-pole, double-throw, quick-break switch . . . is provided with a short-circuiting resistance contact that closes just before the switch is opened from one direction (presumably when the field is opened) and opens just before the switch is closed in the other position."

It looks from this as though the switch should make contact with the 250-volt clips before the short-circuiting resistance is disconnected from the field winding.

The first point to check would be the positive closing of the switch when the field is excited, for if the switch were stalled momentarily and the circuit reopened for a moment, the self-inductance of the field would undoubtedly cause an arc at the clips. Eventually this might cause the field insulation to become punctured.

Suppose that the switch closes properly, but that the short-circuiting re-

The growler at the left is designed for testing armatures up to about 4 in. in diameter. The growler at the right will take armatures up to 30 in. in diameter.



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sistance is removed from across the field before the field is excited from the 250-volt bus, as was stated in the question. The motor is supposed to be up to speed, or practically up to speed, at 2,000 volts. If the motor is actually up to synchronous speed at this voltage, there would be no flashing, disregarding the fact that the application of the exciting voltage might produce a flash as stated above. In starting a synchronous motor, the field winding acts as the secondary of a transformer and at the beginning of the starting period, when the slip is greatest, a very high voltage would be generated in the field, depending upon the frequency with which the magnetic field cuts the motor field turns, and also upon the ratio of the number of field turns to the number of armature turns. This voltage decreases as the speed increases, the slip decreases and the frequency of the m.m.f. acting upon the field turns decreases. Some idea of the voltage generated during this period may be had from the fact that A. I. E. E. standards require an insulation test of 2,500 volts to ground on the field of the machine in question. Now suppose that the machine were not up to speed. It is evident that current will be flowing in the field windings, the amount depending upon the speed of the machine and the value to which it is limited by the short-circuiting resistance. If under this condition the short-circuiting resistance were removed from across the field before the field circuit was closed to the 250-volt bus, a bad flash would result. If flashing is caused from this source it may puncture the field windings, as the voltage at the time the circuit is opened will likely be much higher than the voltage caused by the transformer action due to the self-inductance of the field. Fields of machines designed to start without short-circuiting resistance are required to stand a test to ground of 5,000 volts.

Therefore, I believe that if D. W. B. will adjust his field switch so that the short-circuiting resistance remains across the field until it is excited, look to see if the resistance can possibly be opened due to a jar when closing the switch, and check the mechanical operation of the switch, he should remove his trouble. He might also check up on his rheostat setting and try cutting in more resistance in the field circuit for starting than he uses at present, adjusting the field so that the motor will operate at unity power factor after the running switch of the motor has been closed.

Toronto, Ohio. HERBERT KING.

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In reply to D. W. B. in the November issue, he does not state the size of his motor-generator set, but gives the correct method of starting sets of the usual size. However, it is often the practice with large sets to short circuit the field through resistance, close the starting switch until the highest attainable speed on that tap has been reached, and then close the running switch, at which time the motor should be very near synchronism. The last operation would be closing of the field switch and making the necessary rheostat adjustment. Closing the field switch at this time causes the motor to pull immediately into step with the system.

It is possible that the flash mentioned is the result of the frequency of the induced field current caused by the rotor not being as near synchronism as D. W. B. thinks it is. This current is extremely high at first contact and decreases as the speed of the rotor, with its corresponding frequency, approaches the frequency of the system.

If D. W. B. will obtain a high-grade indicating tachometer and correctly note the speed before throwing in the field switch he can obtain a good idea as to whether or not the above condition exists.

West Allis, Wis. E. J. MORRISSEY.

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In answer to D. W. B. in the November issue, the trouble you are experiencing is due, if I understand correctly your description of the switch, to burrs in the hinge mechanism. Possibly these are behind the spring washers where they are not noticeable. Such burrs are usually of high resistance and would cause the short-circuiting resistance to be partly opened.

Most of these types of switches have extension fingers with high-resistance carbon contacts. If the switch in question has such contacts it is possible that they are not making contact first when the switch is closed and last when it is opened.

It is also possible that there is some trouble, such as a short circuit or other defect in the short-circuiting resistance which permits the passage of more current or a higher voltage than the switch is designed for.

I hope that these suggestions will be of some help to D. W. B.

NICHOLAS J. WEISS.

West New York, N. J.

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Answering D. W. B.'s question in the November issue, his description of the trouble would seem to indicate that the motor is not up to full synchronous speed when the field switch is thrown into the running position. An ammeter in the stator circuit will show definitely when synchronism is reached by falling back to practically zero, with no load on the set. The fact that there is a flash when the switch is thrown from the short-circuiting position would indicate that potential is being induced in the field; this would not be the case if the machine were running at synchronism. The description of the trouble is too limited to make a definite recommendation, but I suggest that the speed of the set be checked at its starting voltage to make sure that it is up to synchronism. If this is found to be the case a slightly higher starting voltage may solve the difficulty, or the amount of field resistance in circuit on starting may be adjusted. It may be that the resistance in the field circuit during starting is not correct and a few tests would readily show whether this is the case. It is assumed that the machine is wired correctly.

C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

Trouble with Collector Rings of Turbo-Generator—We have a 2,300-volt, 60-cycle, 750-kva. three-phase, 3,600-r.p.m. generator driven by a steam turbine. We are experiencing trouble with one of the collector rings carrying direct current for excitation. This ring develops flat spots and what appear to be burned places all around it. The other ring has a fine polish without these spots and flat places. We changed the leads from one ring to the other and the spotted ring was trued up and polished. Then the ring that was first in good shape developed spots and flat places in the first two days after the leads were changed. The brush tension and brushes have been checked and we do not believe that the trouble is due to the brushes, as we are using the manufacturer's brushes. The proper exciting current is maintained and the rings seem to be true, although two years ago one of the rings became very hot and had to be reground as it was a little out of true. These rings are subject to much coal dust and oil vapor, but as the different rings spot up and have flat places all around them at about the same distance apart with the changing of the leads, I do not believe it is due to dirt. I should like very much to hear from others who have overcome trouble of this sort.

Zeigler, Ill. E. P.

As a possible suggestion of the cause of E. P.'s troubles as cited in a recent issue, I might relate our own experience with a 937-kva. turbo-generator with direct-connected exciter.

We had similar trouble and remedied it by turning the rings down true, purchasing an extra hard brush and increasing the pressure slightly on the new brushes.

The theory that I advance for this trouble is this: The ring on the negative side would always be the one affected. This brush would leave a slight deposit on the ring with every revolution and turning at 3,600 r.p.m. it would not take more than a few seconds to cause the brush to actually break contact with the ring, which causes the ring to burn and flatten out. In the event that the rings have to be turned true this should be done with the unit running at its rated speed; otherwise the centrifugal force on a ring of large size will tend to flatten it when turning at high speed.

We made the change to Electro-Nite Carbon Co. brushes on April 17, 1924, and since that time there has not been the sign of a spark on our rings and the unit runs at 25 per cent overload almost continuously.

The fact that one ring is light and the other dark in color is due to the negative brush eating away, leaving a dust deposit on the ring.

Rock Island, Ill. W. J. PARK.

* * * *

Replying to E. P. I had a similar experience with a smaller machine. It was a motor-driven generator that supplied the energy for repulsion-induction motors driving a large print shop. In this case both rings would become spotted and flat and, in a few days, the flashing would become so bad that the rotor would have to be removed and the rings turned in a lathe. Repeated turnings did no permanent good, although on each occasion there was temporary relief. The metal of the rings appeared to be flawless and checking of the balance of the rotor indicated it to be perfect. The outfit had not yet been accepted by the customer, who was beginning to get restless and expressed justifiable apprehension as to how many turnings the rings would stand.

On the next, and final, removal of the rotor to have its rings trued, it was

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returned to the manufacturer who tested the rotor on the ways and found the static balance of the rotor to be good. Upon removing the rings and testing the rotor balance without them, however, the balance was found to be off; and a check of the rings showed that their balance was considerably off. Accordingly, a new collector ring unit was obtained and carefully balanced by itself on an arbor. Then the balance of the rotor without the collector ring was perfected. Finally the balanced ring was installed on the balanced rotor and turned after a check of the balance of the complete rotor indicated it to be perfect. After installing this rotor, no further complaint was made.

Brooklyn, N. Y. J. A. HORTON.

* * * *

In a recent issue E. P. recites some troubles with the rings of the rotating field of an alternator. From his description it is evidently either the positive and not the negative, or the negative and not the positive, brush that continually burns.

Several brushes placed round the ring would probably help. These brushes should be in parallel, so that the current enters or leaves at several points of contact. It is also possible that a ring of different composition would give better results.

It seems to me that the manufacturer should be held responsible for this trouble. It is a question of design and should be remedied without charge by the manufacturer of the machine.

Boston, Mass. EDWARD A. GIBBS.

* * * *

In a recent issue E. P. describes trouble with the collector rings of a turbo-alternator. I suggest that his trouble is due to vibration, aggravated by the effects of polarity. Even if the rings are first turned and polished and the brushes fitted as accurately as possible, small sparks will be formed, nevertheless, between the brushes and rings, owing to vibration and lack of sufficient flexibility in the brush rigging to compensate for this. Even when great care is taken in fitting brushes, the fit is far from perfect and under high ring speed sparks are certain to form between all the brushes and the rings.

Many years ago I had charge, along with several other makes of generators, of a Thomson-Houston A6 alternator which had in its armature, in addition to the regular 1,110-volt, a.c. winding, a low-voltage winding for excitation purposes. The current from this winding was quite heavy and was carried by two wires through a lengthwise hole in the center of the shaft to a rectifying commutator on the end of the shaft, outside of the bearing. As the shaft was slightly sprung the brushes vibrated excessively with attendant sparking. The commutator blackened and burned flat only under the positive brushes, and suffered more than the brushes. Under the negative brushes, the commutator had a good polish, but the brushes suffered.

I had already observed that when throwing a d.c. switch under load, burning, due to the sparks formed, is always worse on the positive side. I concluded that this action explained the trouble with the commutator brushes on the alternator. From these observations, I am inclined to believe that the sparks formed in E. P.'s case soon develop into arcs which burn the positive ring flat as described and also have a more or less detrimental effect on the negative brushes. The fact that the burning was shifted to the other ring, which ordinarily does not give trouble, when he changed the leads and consequently the polarities, seems to bear out this idea. I surmise that his rings are of either cast steel or else a fine grade of chilled cast iron. I would suggest that he grind the rings true in the running position with a portable grinder and carefully refit the brushes; then at intervals of a week or so reverse the leads and he will find that his trouble is considerably reduced. Of course, the cause of vibration should be located and removed, even if the use of a modern balancing machine is required.

We have a turbo outfit which behaves about like his does and if we had to use it much we would have it balanced, but as it is we manage to get along with it. This machine has steel rings and multiple brushes which give good flexibility but not enough to eliminate trouble entirely. We also have an alternator which is direct connected to a 200-r.p.m. engine. This has a revolving field fed through multiple brushes on steel rings. The peripheral velocity of the rings is low, compared to that of our turbo rings, and I can honestly say that since this machine was started August 1, 1908, not a thing has been done to either the rings or brushes at any time. The original brushes are still in use and giving excellent service and the rings still preserve their original polish. This can be ascribed to the low peripheral speed, absence of vibration and great flexibility in the brush rigging.

We also have another turbo outfit which was started in the Fall of 1914, and beyond wearing down, the rings on this machine are in good condition for the above reasons. There is an entire absence of vibration, although the speed is quite high, and another favorable condition is that the rings are of copper, designed for the purpose. If E. P.'s rings were made of copper, his troubles would be less, all other conditions remaining the same. Even if one of his rings were made of copper, and always kept positive in polarity, his troubles would be less. This is reasonable when one considers the remarkable service given by the copper electrodes in the magnetite arc. I think that collector rings should always be made of copper or a copper alloy, as these have good wearing qualities as well as the ability to resist the detrimental effect of the arc formed in conjunction with high speed and carbon brushes, which do not always go well hand-in-hand.

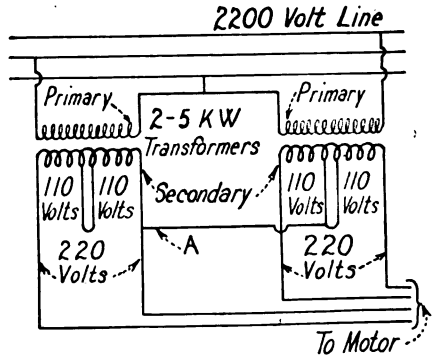
Some years ago the Wirt Electric Co., Philadelphia, Pa., sent us some special metal brushes which I found were not suited to the use we had planned to make of them. Rather than scrap them, I used them on the collector rings of our alternator, with exceptional results. To this day, I would prefer them to carbon brushes of any sort.

In addition to the possible causes mentioned above, of E. P.'s trouble, I might suggest lack of homogeneity in the ring metal as a cause of his trouble, although I am inclined to think that this is not the case.

Chief Electrician, HENRY MULFORD.
Patchogue Electric Light Co.,
Patchogue, N. Y.

* * * *

Trouble in Operating Two-Phase Arc Welder Set on Three-phase Circuit—I had occasion recently to operate a two-phase, four-wire, 220-volt, 60-cycle, 1,800 r.p.m. 5-hp. Lincoln motor, which is direct connected to a Lincoln welding generator on a three-phase, 2,200-volt, 60-cycle circuit. The transformer connection shown was tried. I found that the motor would start but in a short time would get very hot. The wire at *A* was cut and then the motor did not heat so much, so that by stopping the machine about every hour and letting it cool off I was



able to do the welding, but too much time was lost. I wish some of the readers of INDUSTRIAL ENGINEER would tell me if this connection is correct, and if so, what causes the motor to heat.

Tyrone, Pa. H. L. F.

In answer to H. L. F.'s questions in a recent issue the connection at (A) in his diagram should have no effect on the heating of the motor unless the motor windings are interconnected, either intentionally or by both windings being grounded (assuming that the transformer secondary is ungrounded), thereby forming an interconnection.

The voltage distribution with (A) connected as shown in his diagram is indicated in Fig. 1. If the motor is clear of grounds and not interconnected between phases, the voltages between (A) and (D) and (B) and (D) will not cause current to flow in the motor windings. Should, however, the winding be interconnected, say at (O), the voltage between (B) and (D) will cause current to flow at 292 volts in windings (HO) and (OF) of the motor. Heating would also be caused by reason of the phase angle being changed from 90 deg. to 120 deg.

With connection (A) cut the connection at (O) would not cause heating of the winding. The heating noted under this condition would be due to phase displacement only. It is evident that H. L. F. was confronted with a condition over which he did not have control and it was "up to him" to do the best he could with the equipment available, which was probably standard 10-to-1 transformers.

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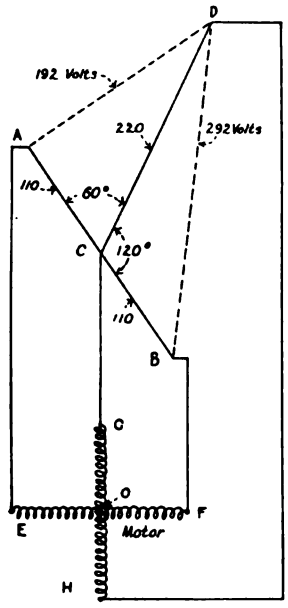


Fig. 1—Voltage distribution to motor windings with connection employed by H. L. F.

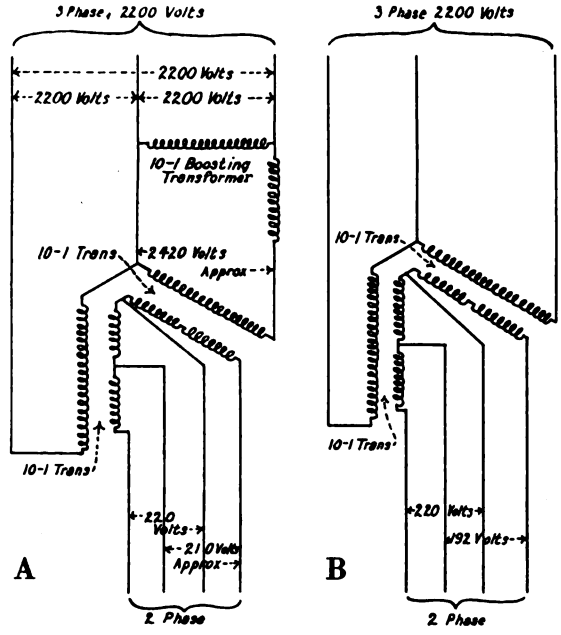


Fig. 2—Suggested connection for operating a two-phase motor from a three-phase supply. In (A) a small booster transformer is used to raise the voltage in one leg.

If the transformers had been connected in open delta on both primary and secondary sides and the motor connected as shown in (B) of Fig. 2, the two-phase currents would have been 90 deg. apart, but one phase would have had 13.4 per cent lower voltage. If a small transformer (approximately 10 per cent of the capacity of one of the main transformers) had been connected as in (A) of Fig. 2 to boost the applied voltage on one leg as indicated, the two-phase voltage would have been as shown, with a very slight displacement of the phase angle.

The suggestions illustrated in Fig. 2 are made on the assumption that transformers available were standard 10-to-1 ratio. If one transformer were 9-to-1 ratio the boosting transformer would not be required. With the connections shown in (A) or (B) of Fig. 2, the motor would still heat if both windings were grounded or interconnected.

Wilmington, N. C. CHARLES R. SUGG.

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Should Coils Be Purchased or Made in the Repair Shop?—We have in our plant about 1,000 motors ranging from 3 hp. to 100 hp. Roughly, one-third of these are older-type motors, while the remainder are of modern type. We have our repair shop, but so far have not attempted to wind our own coils. There is a feeling that we should do this, but before making any decision I should like to get the opinions of readers of INDUSTRIAL ENGINEER on the feasibility of doing this work. Will it pay us to do it? Can anyone give me some idea of the nature and approximate cost of the equipment needed?

I shall be very grateful for any information or suggestions you can give me.

Chicago, Ill. L. A. M.

The question by L. A. M. in the December issue, may be answered by citing the writer's experience in establishing a coil-winding section in the electrical department of a large industrial plant with which he was formerly connected. The first coil-winding equipment was put in about seven years ago at a time when about 700 motors were installed; at the present time there are about 1,500 motors in that plant.

The reasons for installing this equipment were: (1) A large stock of factory-made coils were of necessity kept on hand and after a year or so on the shelf the coils became brittle and the varnish would crack when the coils were put into a motor, thus causing an early insulation failure due to the entrance of moisture and oil into the coil. (2) Often, deliveries can not promptly be made from the factory and if several motors failed, all of the same type, serious delays would result. (3) The interest charges on several thousand dollars worth of rapidly-depreciating factory-made coils are a large item of expense, compared to the storeroom charges on about one-fourth the same amount of money invested in an equivalent stock of double-cotton-covered magnet wire. The amount of varnish and other supplies used is relatively small. Labor charges accumulate only as the coils are made up and put to work.

It is sometimes pointed out that a large amount of overhead should be charged against the coil-making costs. This is seldom the case in an industrial plant as about the same amount of factory space is occupied by factory-made coils as is necessary for the combined magnet wire storage and coil-making shop. Supervision is furnished by the repair shop foreman and the overhead necessary to be added is negligible.

For handling the repairs on 1,000 motors the equipment suggested would include one lathe-head-type, loop coil winder belted to a motor of about 2-hp. rating; one hand-operated coil spreader or former; two shallow varnish dipping tanks with drain racks; and one sheet metal or brick baking oven with about 2½ in. of heat insulation. The heat may be furnished by a gas-fired, convection-type heater, the products of combustion being piped outside of the building. The ventilation of the oven is important in order to provide oxygen to oxidize the varnish. The baking temperature should be maintained at a constant value suggested by the varnish maker. Considerable information on this subject has appeared in previous issues of INDUSTRIAL ENGINEER.

After a careful inspection of various motor manufacturers' plants the following coil-winding practice was adopted and has been in continuous use for a number of years: Double-cotton-covered magnet wire is used for making the straight, hair-pin loop coil. The coil is bound at intervals with lead strips and removed from the winder. The lint is burned off by quickly passing the coils once over a small gas flame and they are dipped in a fairly heavy, black, elastic baking varnish and allowed to drain. The coils are then placed in the baking oven and remain at the proper temperature for about 12 or 14 hr., care being taken not to overheat the varnish, which becomes brittle under such treatment. The loops are then spread or formed to a diamond shape and taped with a half-lapped layer of empire tape and a half-lapped layer of linen tape. Following this the coils are singed and dipped in a clear, elastic baking varnish and baked. This latter dipping and baking operation is repeated two or three times, until the coils present a smooth, glossy and continuous film.

The cost of coils made in the industrial plant will vary from one-third to two thirds the cost of factory-made coils, depending on the size of the motor, local labor costs and the expertness of the operators, who should preferably be women. The quality of the work should be equal to that of the factory coil and in some cases exceeds it, while for a large plant the economy is unquestionable.

As regards the cost of the equipment, a number of satisfactory outfits are now on the market, but quotations will have to be obtained and the cost estimated for each installation.

Alcoa, Tenn. J. ELMER HOUSLEY.

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Answering L. A. M. in the December issue, the making of coils is one of the most important steps in the process of rewinding d.c. or a.c. motors; in fact a good set of coils is the foundation upon which a long-life, rewind job is built. By a good set of coils I do not mean coils that look nice, but those in which have been incorporated all the best features known. That includes the best of insulation and wire, applied in such a manner as to withstand the hard knocks of service.

To meet the above conditions requires that the coil-manufacturing equipment installed must be of the best, as well as the material carried on hand. Magnet wire for example, comes in a variety of sizes, and types of insulation. Thus, we have round, square and ribbon wire, and the insulation on the wire includes single-cotton-covered, enameled, single-cotton and enamel, double-cotton and enamel, and asbestos-covered. In a great majority of cases the wire sizes will be duplicated in differ-

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ent insulations, or in round and square. This means that the larger the plant the greater will be the amount of money tied up in wire. Then we have insulating material, consisting of cotton and linen tapes of different widths and thickness, treated tapes of at least two widths and grades, and mica tape. Then comes insulation in sheet form for coil wrappers; this includes mica and fish-paper, pure flexible mica, and treated cloth in the yellow and black grades. Also we require three different grades of insulating varnishes, as well as insulating glue, twine and flax cord. The majority of this material deteriorates with age and if not used within a reasonable time it becomes hard and loses its maximum insulating qualities.

But what is more important is the type of man available to take care of the coil department. This man should know, in fact must know, how to design and lay out any type of coil so that it will fit into the proper slots and have the proper end space and shape, so as to eliminate pounding a finished coil to shape. The coil man must know the principles of a.c. and d.c. windings; he must know what insulating material is available and its good and weak points and how to select the various items that make up a coil, to withstand different applications.

To illustrate, I have in mind a case where we had a large d.c. armature to repair. It had four conductors per slot and these conductors were shaped and joined together with clips at front and rear to form a winding that was the equivalent of a 2-turn coil, 2-circuit, wave winding, but each coil consisted of eight conductors and had three soldered joints. The coil man figured out the winding and made a 2-turn coil with one lead on top and one on the bottom, which eliminated the soldered joints and saved considerable winding time. What is more important however, it eliminated trouble that occurred from time to time due to the soldered joints. This was an advantage that was well worth considering.

From my 15 years of experience in repairing all kinds and makes of electrical machines, I can say that the grade of work put into a coil determines the life of that particular rewind job. This applies to the simple mush coil as well as the more elaborate coils.

The following are a few of the details that insure good coils. This list can be used for checking purposes in plants that make or intend to make their own coils, to determine how close they come to a grade A 1 coil.

(1) Are all materials used in the coils purchased according to exact specifications, thus insuring the best of everything?

(2) Are all coils wound in such a manner as to guarantee that all wires will be in proper relation to each other, using special tools or forms if necessary to meet above conditions?

(3) Are the points most susceptible to trouble—such as, crossovers, corners, curves, angles and points where the leads leave the coil—reinforced for insulation, strength and rigidity?

(4) Are the leads reinforced with extra insulation and the extra insulation firmly secured to the coil, and the leads reinforced to prevent slippage?

(5) Is it standard practice to dip the coils after pulling or shaping, and before insulating, in a good grade of baking varnish?

(6) Are the coils thoroughly insulated; that is, is the insulation put on the coils and not in the slots while winding the machine?

(7) Are the coils given a final dip, after insulating, in a high-grade baking varnish?

(8) Are the leads of all coils, a.c. or d.c. tinned before they are given over to the winding department?

(9) Are the coils inspected between operations and given a final test for shorts, etc.?

The above points should be considered when contemplating the installation of a coil-winding department and, as stated before, the more attention that is paid to them, the greater will be the life of rewind jobs.

Wilkinsburg, Pa. A. C. ROE.

* * * *

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43." means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.

Mazatlan, Sinaloa, Mex. J. C. L.

Referring to J. C. L.'s query in a recent issue, the motor in question is sometimes equipped with small cast-iron plates which cover the openings in the endshields and make it an entirely-closed type. As the capacity of a machine is limited by the temperature reached by its windings, it is obvious that the heat would be more readily dissipated in the case of an open-type motor than with a closed type; consequently the rating will be higher.

In the open type there is a constant current of air through the windings caused principally by the rotation of the armature, warm air being replaced by cool air from the outside. Since this is not possible in the enclosed type, the allowable temperature rise would be reached at a much lower current density in its conductors; hence the reduced rating. In an attempt to facilitate the dissipation of heat in enclosed types, manufacturers often resort to radiating fins which are either cast integral with, or riveted to, the frame and end-shields. To the writer's knowledge a certain frame with a given winding often has a rating 100 per cent higher when it is of the open type, than when it is of the completely-enclosed type. The double rating of machines was formerly more in use than at present.

The A. I. E. E. specifications, June 28, 1916, state that:

"An open machine is either of the pedestal or end-bracket type where there is no restriction to ventilation other than that necessitated by good mechanical construction.

"An enclosed machine is so completely enclosed by integral or auxiliary covers as to prevent a circulation of air between the inside and outside of its case, but not sufficient to be termed airtight."

Denver, Colo. EDWARD H. HAUSLER.

In reply to J. C. L.'s recent question, in some plants a motor is completely enclosed in a wooden or metal box so that the ventilation is shut off, or the end bells may be solid.

If a motor is so enclosed, it will get as warm when pulling a 5½ hp. load, say, as it would pulling a 10 hp. load in the open. The practical application of the nameplate data on J. C. L.'s motor is, that if the motor is to be run enclosed, the load must be reduced to approximately one-half of the normal open rating.

Peoria, Ill. GEORGE RINGNESS.

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Grounding Secondary of 3-Phase, 220-440-Volt Distribution System—I wish some reader would tell me whether the secondary of a three-phase distribution system for 220-volt and 440-volt motors should or should not be grounded? Why? The Standard Handbook says: "The grounding of secondaries up to 150 volts has been required by the National Electrical Code since 1913. There is some doubt as to the advisability of grounding secondaries when the difference of potential between any wire and ground is higher than 250 volts, owing to the possibility that shocks from such a system may prove fatal." How could a person receive a shock from a grounded secondary system when the conduit inside of the building is also grounded? Would not trouble at once reveal itself? I shall appreciate it if you can enlighten me on the why's and where's of this subject.

Orlando, Fla. H. C. M.

H. C. M. asked an interesting question on the grounding of three-phase secondary systems carrying 220 or 440 volts. However, I think that he has answered his own inquiry of "why?" It is the practice hereabouts to do as he states; that is, ground no secondary over 230 volts because of strain on the insulation of the conductors.

As he says, a person cannot receive a shock from a grounded secondary system when the conduit is also grounded, unless the ungrounded wire is touched, or the ground wire has become disconnected.

Boston, Mass. EDWARD A. GIBBS.

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In answer to H. C. M. in a recent issue, the secondary of a three-phase, 220-440-volt system should be grounded for the personal safety of operators, although grounding is not compulsory, only optional, by the Code rules.

If the primary high voltage should break down its insulation and cross with the secondary winding there is a possibility of an operator getting a fatal shock from ungrounded apparatus, whereas, if the secondary were grounded, the primary fuse, on the power-house side, would likely blow, or the detector show a bad ground.

On the other hand, grounding the secondary increases the fire risk, for with one leg of a 440-volt line metallically grounded, if the other leg breaks down there will be a short circuit, which at this pressure will likely start a dangerous arc.

One way of handling the situation is to not ground the secondary, but to rely upon a ground detector located on the main switch-board. If lamps are used for this, connect them across the main secondary feeders permanently. If a voltmeter is used, arrange the connections so that a testing plug can

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be inserted. Testing should be done frequently, so as to discover a ground as soon as possible.

Lamps used as a ground detector make a real good tell-tale, as they will show a ground steadily until it is removed; also, a "make and break" ground will show a repeated flicker, which is very noticeable. Lamps cannot however show the voltage of any ground.

The voltmeter detector can be used on only one leg of the system at a time, and although it is not as conspicuous in action as are lamps, it will indicate the exact voltage of any ground.

New Britain, Conn. H. S. RICH.

* * * *

In answer to the question asked by H. C. M. in a late issue of INDUSTRIAL ENGINEER, in practice nearly all secondary distribution systems are grounded, except secondary systems operating at high voltages. The reasons for grounding are: (1) To minimize life hazard. (2) To short-circuit static. (3) To insure continuity of service. (4) To provide a ground-detector connection.

The objections to secondary grounding are: (1) An accidental ground on a secondary conductor (if of opposite polarity to the permanent ground) may and probably will, interfere with the service. (2) With the permanent ground on the secondary circuit, if the ground wire is connected to one of the outside wires of the secondary system, there then exists between the other wire of the circuit, the conductor of opposite polarity, and the ground the full voltage of the secondary circuit. (3) Grounding of the secondary circuit may cause difficulties when tests are being made. (4) Permanent grounds increase the expense of installation.

The reason why secondary grounding of systems of 150 volts or less decreases life hazard is that an accidental cross between the primary and secondary of a transformer may cause a voltage equal to that of the primary circuit to exist, if the transformer secondary is not grounded, between the ground and any current-carrying parts of the secondary system. This is the case if there is a ground, permanent or accidental, on the primary. Even if there is no ground on the primary there may be electrostatic capacity enough to cause danger to any one standing on or in electrical connection with the ground, and touching any unguarded current-carrying parts of the secondary system.

The Code does not require secondary systems of over 150 volts to be grounded for the reason that higher voltages between the ground, or grounded point, and any other point in the circuit are dangerous to persons standing on the ground or electrically connected to it and touching a wire of opposite polarity. In this case there need be no accidental cross on the primary.

If secondary systems of 150 volts or more are installed in conduit and the conduit is grounded, and effectively grounded, the above-mentioned dangers do not exist so long as there are no unguarded current-carrying parts. Trouble, as a ground on opposite polarity within the conduit tubing, would probably cause a current strong enough to blow fuses or trip the breaker protecting the system.

Concord, Mass. DONALD FERGUSON.

* * * *

H. C. M.'s question in a late issue deserves more than a perfunctory answer, as it brings up a number of points that must be settled by the operating man for each particular system concerned, with reference to the actual requirements of the case.

A direct reply to the question should, I think, be prefaced by some comments concerning the general subject of grounding. Grounding may be considered from the following three standpoints:

(1) Grounding to reduce the life hazard.

(2) Grounding to safeguard equipment.

(3) Grounding to improve operation.

(1) The desirability of limiting the maximum voltage to ground in circuits where it is possible for a person to come into actual contact with a live conductor is now fully recognized by all controlling bodies as well as operating companies. It is limited in the main to lighting circuits where burned-out lamps or fuses may be replaced by inexperienced persons who may readily come in contact with an exposed conductor.

The limit of 150 volts is in fact more or less arbitrary, as the exact voltage dangerous to life has not been definitely established. In up-to-date motor wiring where the switching and control equipment is always more or less, if not totally, enclosed the danger of direct contact is very remote. It is desirable, however, that the frame of each motor as well as the metal frames or containers of each piece of control equipment be well grounded, to protect anyone that might come in contact with them.

This applies especially to equipment mounted on an insulating supporting structure, in which case the connection of the winding to the frame or part of the circuit to the metal work might allow a considerable difference of potential to exist between frame and ground without any visible indication. Anyone touching the frame might, under certain conditions, receive full voltage to ground. If the frame were grounded this danger could not possibly exist.

(2) With an ungrounded system it is possible to have one conductor actually grounded for some time without any indications of trouble, but during that period the insulation may be weakened by the flow to ground of even a small current through partial grounds on the other conductors. Due to the poor contacts that usually exist in these cases, aided by moisture or semi-conducting dust, the insulation may char for some time and the ultimate result may be serious breakdown in the equipment. While this trouble is more pronounced at voltages above 250 it can readily occur at even lower voltages. Obviously, by solidly grounding such a system cumulative trouble can be prevented by making a ground noticeable as soon as it occurs.

(3) Supplementing section (2) the question of continuous operation is always paramount. A well-known stock argument against operating with a grounded system is the statement that a ground in any motor winding may cause an interruption of service. Experience indicates, however, that this is not the case, as grounded systems actually give less trouble. In fact the existence of a ground is immediately shown by the blowing of a fuse or the tripping of a circuit breaker, or other indication. As a result it is necessary to clear up any trouble immediately and also to give better attention to the condition of the motor windings, which in turn results in shorter delays and better service.

Coming now to the direct answer to the question, it is assumed that the installation is supplied with current from an outside source, although in general similar methods may be used for isolated plants.

For a 220-volt system the grounding can readily be accomplished by installing grounding transformers connected in star and grounding the neutral connection; this will give a maximum of $220 \div \sqrt{3}$ or 127 volts to ground, which is of course, well within the requirements of the National Electrical Code. In establishing this type of grounded system the secondaries of the grounding transformers should be connected in closed delta so as to reduce the impedance of the ground circuit to a minimum and allow the current to pass readily in case a bad ground should occur.

For a 440-volt system the grounding may be similarly accomplished, giving a maximum of 253 volts to ground. While this exceeds the value of 150 volts previously referred to the fact that the control equipment may be entirely enclosed and the frame of a motor solidly grounded makes the possibility of danger to an operator extremely remote. One of the largest electrical manufacturing concerns in this country has operated for many years with such a system without a single case of injury which could be attributed to shock due to the system used.

The question asked regarding the possibility of a person receiving a shock due to a ground inside of conduit when the conduit itself is grounded is answered by the foregoing discussion. It is not possible to receive any appreciable shock from a reasonably well grounded system, and the trouble gives a definite indication immediately when it occurs.

Summing up the matter, the following points deserve particular consideration: (a) Grounding a three-phase system establishes a definite maximum potential to ground, as compared with a varying potential for an ungrounded system, which potential may reach the maximum potential between phases. (b) An ungrounded system is an unstable one which can easily develop serious trouble because defects do not become evident, until they are quite serious.

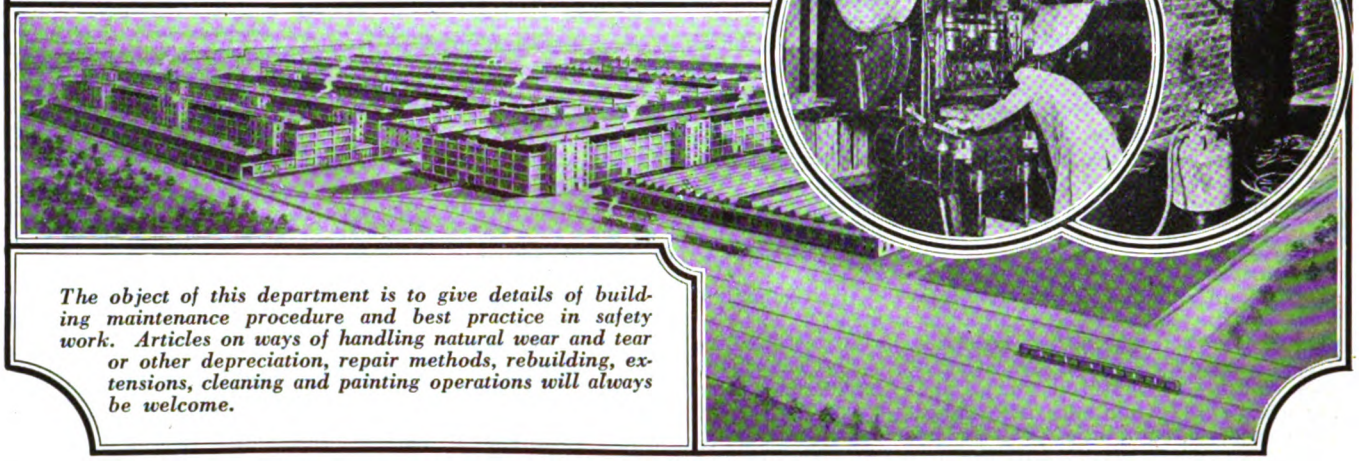
In other words, there can be no serious objection to operating three-phase 220-volt and 440-volt distribution systems properly grounded.

C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp., New York, N. Y.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Two Ways to Get Longer Life From Eaves Troughs

EAVES troughs are more or less of a problem in building maintenance. If the runs are long, as they generally are, the difference in expansion between the metal trough and the building (especially if it has a concrete roof slab) is considerable. If the trough is suitably hung and braced, it expands more than the building, and leaks develop in the joints. Sometimes the expansion strains pull rivets or shear them.

We went over the eaves troughs at this plant recently, and riveted a piece of galvanized iron across each joint. This was fitted to the inside of the trough, and extended 10 in. or 12 in. each side of the joint. These pieces were riveted well and soldered at the ends. This arrangement has, we believe, added five or six years to the life of the troughs as the metal was perfectly good, excepting at the joints where expansion and ice strains had broken solder and rivets.

The outside was painted with a good metal paint, and the inside with an elastic roof paint. The cost of this repair was approximately 7 per cent of a new set of troughs. The job has transformed a long sieve into a real eaves trough.

A neighboring plant has solved a similar expansion problem by dividing the troughs into 50-ft. sections and grading with a steep pitch each pair of 50-ft. sections to a center downspout. The downspout is connected to a sewer-tile drain laid parallel to the building. This gives a downspout in the center of each 100 ft. of eaves trough.

The advantages are steep pitches, expansion well taken care of and longer life of the installation. Balanced against this is the extra cost of downspouts, which is a small percentage of the total building cost.

In new construction see that the trough specifications call for heavy metal, heavy braces, short lengths, good pitch, plenty of downspouts and a way to dispose of the water after it is off the roof. Keep the troughs well painted both inside and out, and while they may not be a thing of beauty, they will be a joy, for a long time at least.

Plant Engineer, Gardner Machine Co., Beloit, Wis. S. W. STEARNS.

Method of Preventing Rods From Turning With Turnbuckle

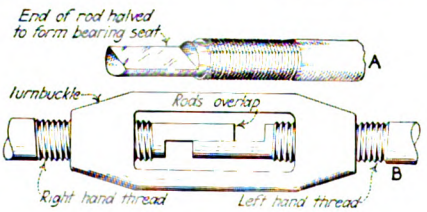
IN TIGHTENING turnbuckles, it is usually necessary to place a pipe wrench on one or the other of the two rods being tightened in order to prevent them from turning or being loosened from the connection at the other end of the rod.

If the ends of the rods are halved as shown at (A) in the accompanying illustration, they can be prevented from turning when assembled with the turnbuckle, as shown at (B).

When tightening or loosening the turnbuckle, the rods will now tend to turn together. They will not turn, however, for one rod or the other will tighten into the nut or socket on its other end and thus prevent rotation.

This is a simple idea which is easily applied to any turnbuckle, where the length of the rods is sufficient for threading and halving the end.

Washington, D. C. G. A. LUERS.



The ends of the rods in the turnbuckle are halved as shown at A.

When assembled as shown at *B*, both rods tend to turn together. This is not possible, however, because of the end connections on the rods and in consequence the rods do not turn, when the turnbuckle is moved in either direction.

Simple Method of Cleaning Sludge From Fuel Oil Tanks

SLUDGE is a black, sticky asphaltic "end" contained in fuel oil. It emulsifies with water forming an incombustible mass in some cases, chokes strainers and pipe lines, carbonizes burners, causes smoke, and when used as a fuel for Diesel or internal combustion engines, jeopardizes the cylinder walls and valve motion by introducing sand or grit that is entrained. When cleaning fuel oil tanks and pipe lines everybody around the plant from the "Old Man" to the oilers are smeared with the black, sticky, smelly, oily substance. It is a disagreeable, costly job at best.

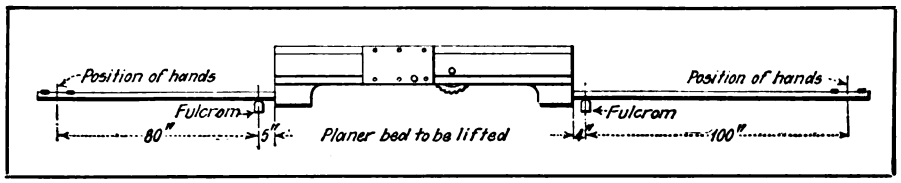
There are several methods now used to handle this proposition. The old-time method was to pump as much oil and sludge out as possible. Then the tank was opened and laborers in rubber boots with shovels, hose and buckets, scooped and bailed out the remainder. A wash-down with kerosene and brushes and a subsequent wiping out with rags followed. It was a long, hard job, expensive because the labor factor was the predominant cost, and dangerous because of the deadly gases contained within the tanks. This made it necessary to air the tanks even after filling with water for as long as 48 hr. after emptying.

The first advance came when high-pressure steam was introduced to the job. The heat of the steam served to lower the viscosity of the sludge and permit more complete emptying of the tank with pumps and bleeder lines. Then, too, the side walls and top were cleaned more or less by the heat and moisture of the steam.

Some of the large oil companies resorted to the use of naphtha after the tank was wiped down and subsequently re-distilled the naphtha. This was more effective, but the use of this material is prohibited in most plants, due to cost and fire hazard. Moreover, the tanks must still be wiped by hand.

With this in mind, engineers turned

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How a heavy planer bed was weighed without the use of scales.

The weight of each end was found approximately by determining the weight required on the outer end of a lever, supported by a fulcrum, to balance the weight of the bed. The distance of the fulcrum from each end of the lever was known and when the weight required to balance the planer bed was determined the weight of the latter was calculated by simple proportion.

to lye. Here was a means of cleaning oil out without expensive hand wiping. Accordingly the tank was emptied and a hot, strong solution of "lye" (sodium-hydroxide), was pumped in and a steam line connected. After about an 8- or 10-hr. boil the solution was pumped out. The tank was much cleaner but here and there, particularly around seams and rivets, it was necessary to wipe it down. However, the strong caustic vapors made life miserable about the place; overalls fell to pieces, skin peeled off the men's arms and faces, and in some cases, "caustic boils" appeared in a few days.

Search was then made for a material that would either modify the alkali effectively or replace the use of caustic entirely, and be commercially practicable. Many materials that were found to be effective in the laboratory, were impractical because of cost of manufacture. Finally a method of using alkali was found, so that it would not cause burns nor poison sores, and yet was effective.

Briefly the process is as follows: A hot solution of 4 to 6 oz. per gal. of a special compound (International Chemical Co., Philadelphia, Pa.) is run into the tank. A live steam hose from a small portable boiler is inserted into the compartment and the whole mass boiled for one hour. During this time the sludge is loosened and emulsified and floats to the top. The condensing steam adds just enough water to the tank to cause this emulsion to overflow the vent pipe and thus carry away the loosened oil. At the end of the hour, the solution is transferred to the next tank or compartment and the process repeated. There are no objectionable odors. A flame may be carried with perfect safety into the tank as soon as it is emptied. The entire tank is clean; seams, rivets, corners—in fact, water-white gasoline may be carried without contamination.

The cost is extremely low; about 2 cents per gal. for the solution and a minimum of hard labor are required. There is no wiping; the tanks are simply boiled out and emptied. In the case of ships the time required for cleaning the tanks is reduced from approximately two weeks to one day. The saving in this case is large.

The same method may be used for cleaning tank cars as well as fixed tanks. In tank car cleaning one solution can be re-used on as many as seven to ten cars, depending on the amount lost in transfer, evaporation and otherwise. To clean pipe lines, it is only necessary to pump the solution through them. Where there is a circulating system, this is very simple matter, as the solution will not injure pumps, valves or strainers. The cleaning solution may also be used to clean up the floor, walls and pumping machinery.

Technical Division, W. B. CLARKE.
International Chemical Co.,
Philadelphia, Pa.

Using Lever to Find Weight of Heavy Machine Parts

OFTEN it is desired to know the weight of pieces that are too heavy for scales at hand or that are so located that they could not be weighed even if there were available scales of the proper capacity.

Complete machines or heavy castings are not readily moved about under the best of circumstances. The heaviest spring balances in ordinary use run only to 500 lb., while the average platform scale of the portable or pit type weighs up to 1 ton—these are useless for all but "light" machinery.

A knowledge of the weight of bulky parts is desirable for many reasons, such as, to prevent overloading floors, to properly fill out shipping forms, to build adequate foundations, and to safeguard men and handling facilities.

The worst kind of accidents have been caused by weak blocking, flimsily built supports, machines that have been raised with a bar or otherwise and, lacking proper balancing, have toppled over on an unfortunate workman, or parts that were being erected from scaffolding by main strength or suspended from frail slings. Not realizing the weights involved and the danger resulting from the least slip, millwrighting is carried on in this way and, when the slip does occur, the part always comes DOWN.

In the case of a new machine, weights may be obtained from the makers, but with one that has seen many years of service, there is generally no way to get the weight except by an actual scale reading or its equivalent. A computation by volume may be only an approximation because of inaccessible portions and irregular shapes which make the computation only a high-brow guess. When it comes to moving such pieces from floor to floor or out of a building, cranes and floors may show up their weakness and an accident result. It is not necessary to consider the heaviest equipment, in order to see how true this is. Machines about the size of a No. 4 Toledo press, a 20-hp. steam engine or a 40-in. planer will serve as illustrations. What would happen if 2-ton handling equipment were all that was available for moving these?

The lever provides a means of checking the weight of almost any piece up to 30 tons. With a fulcrum placed close to the part of unknown weight and a suitable lever, one or more men or a known weight can be placed at measured distances to balance the load. This procedure repeated at the two ends of a part will give the weight sufficiently accurately for all practical purposes. The calculations are by inverse proportion of the simplest kind.

The accompanying drawing shows how a planer was weighed. The machine was being rebuilt in the shop where it was used and one of the jobs was planing the ways on both table and bed. To do this, of course, the machine had to be entirely dismantled and the parts named had to be put on another planer. The table was estimated at 2 tons weight (from volume computation) and this was checked by lever also; this part was within the overhead handling facilities, it was known, but was checked anyway. But the bed was much heavier and it had to be lifted 36 in. from the floor and then moved sidewise to an adjoining planer. What was the weight of that bed? There were too many inside braces, rounded corners and too much core work to get anywhere near the volume by calculation. The simpler method, in any case, is as follows:

A bar of steel was picked out from the stock rack. Then, a block of suitable height for the planer bed's opening was placed between the feet and on this a piece of iron that had been ground off rounded on top. This iron block was placed at a measured distance from the point of application of the lever. The rounded top to the fulcrum is better than a flat surface because the flat top does not offer a definite measuring position inasmuch as the lever moves through an arc.

A 220-lb. workman did the "weighing." He knelt down and rested his whole weight on the free end of the bar, raising himself just clear of the floor in so doing. By successive trials, the position where his weight balanced that of the planer was found. On the drawing, the location of his two hands is shown by heavy black. When the balancing position was found, a measurement was taken from the center of the hands to the planer.

The calculation is as follows:

$$(220 \times 100) \div 4 = 5{,}500 \text{ lb.}$$

Or, by proportion: $220 : x = 4 : 100$. The results are the same in either case. The operation was repeated on the other end; the weight there was found to be 3,520 lb. Thus the weight of the machine part was definitely obtained as the sum of the two weights or 9,020 lb. This was accurate enough for our purpose and enabled us to arrange handling facilities that were both adequate and safe.

When the lever is used for weighing, it is important that it be placed in a horizontal position. If this is not done, a true measure will not be obtained. To arrange the lever in horizontal position, it is only necessary to provide suitable blocking under the fulcrum and to have it slightly "high" rather than low as the weight need be lifted only a half-inch, or thereabouts. Do not try to lift both ends of the machine at the same time as it may tip.

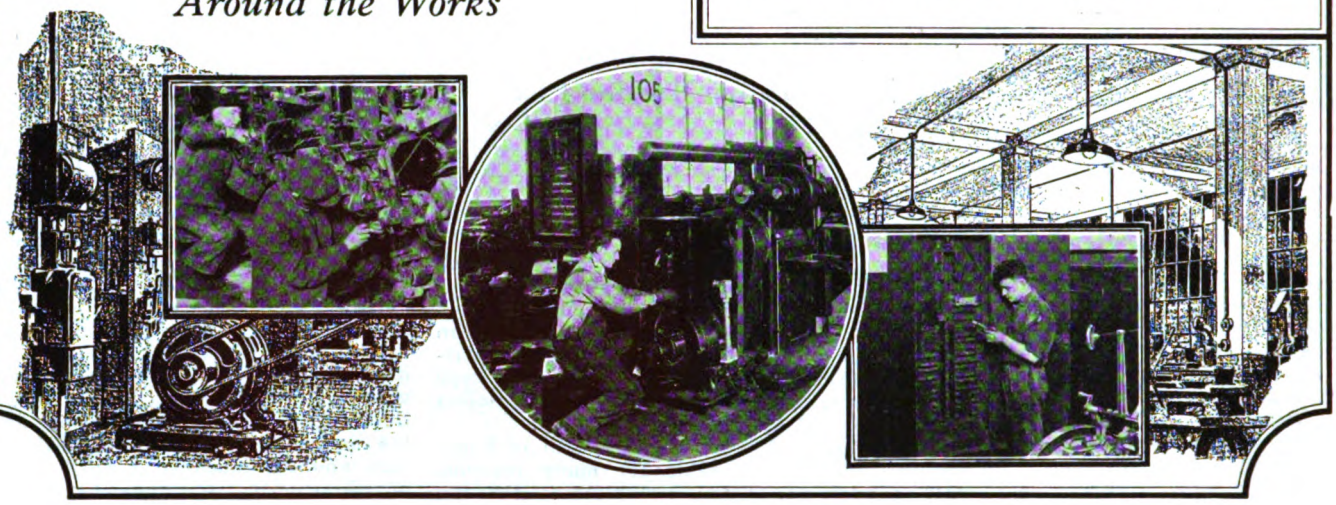
DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Method of Protecting Plug and Receptacle for Portable Machine

INSULATION of a portable sand cutter in a foundry presented a problem in selecting or designing a suitable plug and receptacle and mounting them so as to secure the desired flexibility of operation with the maximum protection from damage.

The sand cutter, which does as much work as four men cutting molding sand, operates 9 hr. a day. It is driven by a 7½-hp. motor and is supplied through a No. 4 line, in order to avoid a heavy voltage drop at full load. The wiring is all in conduit and power receptacles are located at convenient points around the foundry.

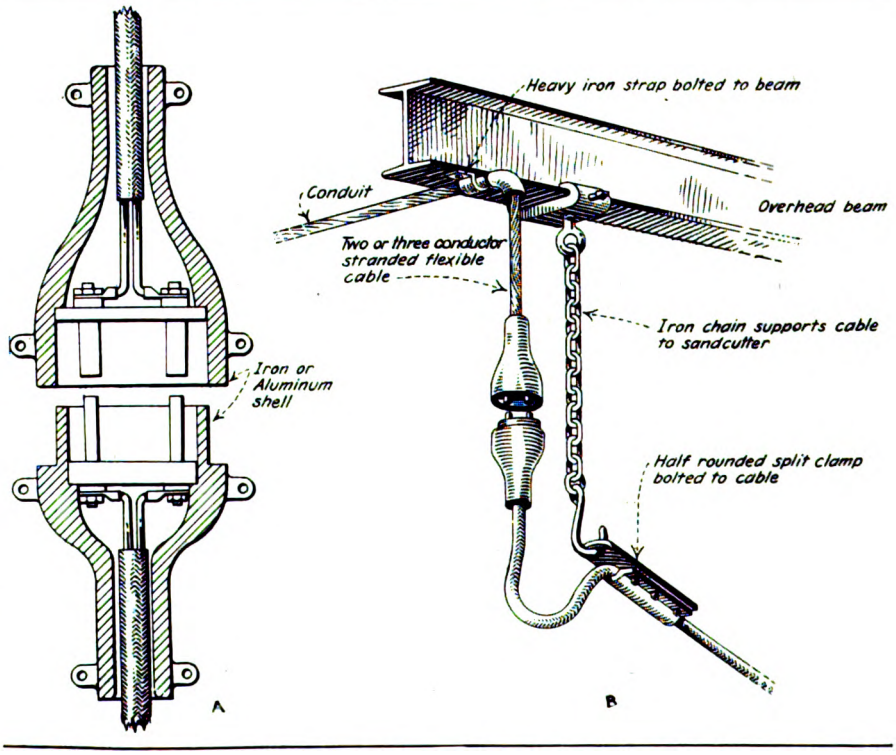
The flexible cable by which the sand cutter is connected to the power receptacle is carried over wooden pulleys to a small reel which is mounted on the sand cutter and driven by a chain so that it automatically pays out or reels up the cable as the machine moves. An adjustable brake band holds the reel just tight enough to prevent slipping.

The type of plug and receptacle shown in (A) of the illustration was adopted for use, and mounted as shown in (B). These plugs and receptacles are split and can be made with an iron, aluminum or hardwood shell. They are about 6 in. long and 3½ in. or 4 in. in diameter, depending on the material used.

Where the contact parts are of the pin-and-tube type, the pins must be tapered and the tubes split to insure tight connection. As will be seen, the receptacle is suspended from the end of the conduit, which is firmly fastened to the supporting I-beam, by a short length of standard, flexible cable. The plug is, of course, connected to the end of the flexible cable on the sand cutter. A half-round, split clamp is bolted around the cable about 3 ft. from the plug. One side of the clamp has a hole at one end to accommodate a hook attached to the loose end of a short length of stout chain which is suspended from a clamp fastened to the I-beam. By this arrangement the weight of the cable is supported by the chain, so that under no circumstances can the plug and receptacle be pulled apart, or any strain be placed on them.

Protected in this manner, the plug and receptacles have not given any trouble. The same scheme could be used to advantage on any piece of portable equipment which requires a heavy, flexible cable, or where there is danger of the cable being pulled.

Jamestown, N. Y. H. S. RICH.



Details of plug and receptacle, A. In B is shown how the flexible cable is supported by a chain suspended from an overhead beam, thus preventing the plug and receptacle from being pulled apart.

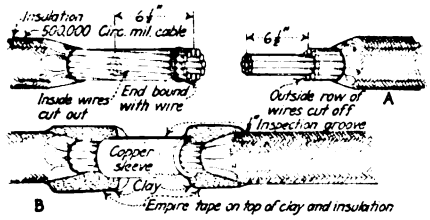
Method of Making a Sleeve Splice on Heavy Cables

IN REVAMPING an existing system of cables behind a switchboard, some of the cables were found to be too short while others were a trifle long. The long ones could be cut off and lugs soldered to them, but the short ones had to be spliced out. There was no strain on the wires and it was decided that a sleeve splice would be the most adaptable. It would have good conductivity, have a fair tensile strength if the sleeve were of sufficient length and would not be too bulky when taped.

The ends of the cables to be spliced were prepared as shown at *A* in the accompanying illustration. As can be

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seen the inside wires were cut out of one cable and the outside row of wires cut off from the other cable, thus making the left hand cable the female end of a joint. After the wires had been well cleaned and fluxed with soldering paste a wooden mandrel was inserted in the female cable and the loose wires



The strands of the two cables are cut and formed as shown at (A).

The male cable is then placed in the female and the joint encircled with a copper sleeve, as shown at *B*. The ends of the sleeve are calked with clay to prevent the melted solder from running out during the soldering operation.

were tightly bound with wire as shown. This was done to hold the wires tightly together after the mandrel was removed.

A copper sleeve was then inserted over this cable in the manner shown at *B* in the illustration, and the male cable inserted into the combination as is shown. When the sleeve is in place, the banding wire around the female cable may be removed. The sleeve should be long enough to extend 1 in. on both sides of the places where the wires were cut. This will hold the joint rigid and prevent it from breaking open when handling and bending the wires while working it into place after the joint is finished and taped.

The copper sleeve can be made from a piece of tubing. An inspection slot, about ⅛ in. wide should be cut through the entire length of the sleeve. In case a piece of tubing is not to be had conveniently, a piece of copper sheet 1/16 in. thick can be tinned on one side, cut to the proper length and width, and bent into shape.

The copper sleeve should be placed with the inspection slot on top. Clay was smeared around the edges of the sleeve to prevent the melted solder from running out of the ends of the joints, and varnished cambric tape wrapped on top of the clay and insulation to keep the latter from charring, and to prevent the clay from flaking off as the joint is dried out by the heat of the torch. The object in using varnished cambric tape under these conditions, is that it neither smokes nor flames up from the fire of the torch, which is a very desirable feature.

The joint was thoroughly heated and kept hot by two torches and melted solder poured from a ladle into the inspection groove of the copper sleeve. Even after the groove becomes full of solder, it is advisable to keep the torch on the joint for a little while, so that the solder will permeate the wire thoroughly.

The torches were removed and the joint cooled slowly by means of a damp rag placed on the under side. As the solder contracted, as was apparent by its disappearing from the groove, more solder was added from the ladle. This contraction will continue before the solder hardens, so that it may be necessary to add more solder two or three times. After each addition of melted solder, apply the torch again for a short interval so that the solder bonds and is homogeneous.

A little practice may be necessary to make a good splice by this method but it is well worth the effort.

Oakland, Calif. S. H. SAMUELS.

Method of Paralleling Alternators Coupled to Same Shaft

THE original installation in a small power house consisted of a 125-kw. alternator and a water wheel of double the power capacity of the generator. Later on the owners had the opportunity of purchasing second-hand an exact duplicate of the original generator, and installed it on the same water wheel shaft. For a while they used either generator on the load, but never used both at the same time as they were only supplying one circuit and the load did not require it. However, when the load, which was a small town lighting load, outgrew the one generator it became desirable to arrange the two machines for simultaneous operation in parallel in order to take care of the load.

The two alternators were mounted on opposite sides of the prime mover, and connected to the waterwheel shaft through couplings as shown in the accompanying diagram. Of course, the only thing to be determined was the exact mechanical relationship of the two fields in order to have them operate with a minimum cross current.

The bolts were removed from the coupling (M) which connects generator (A) to the waterwheel. The two halves of the coupling were then tied together with strings sufficiently strong to permit the alternator to be brought up to speed when the waterwheel was started. Alternator (B) was left permanently coupled to the other end of the shaft. The waterwheel was started and brought up to speed, and the fields of generator (B) and also of generator (A) were partially excited. The switch between the two machines was then closed, the machines pulled into step, and by this operation the relatively weak strings tying the coupling on alternator (A) were broken, leaving machine (A) running independently as a synchronous motor supplied by power from machine (B) running as a generator.

It was only necessary then to bring the voltage up to normal and adjust the excitation of either machine until the circulating current was a minimum. At this point the two machines were of course in correct phase relationship. A chalk line was then stretched across the flanges of the coupling at (M) parallel to the shaft and snapped against the coupling while the machines were running at normal speed. The machines were then stopped and three clearly defined impressions of the chalk line were found on the two flanges of the coupling. The chalk lines on the two flanges were then brought exactly into line and the couplings bolted together in the new and correct position.

It was necessary to ream out the holes in one-half of the coupling in order to bolt it together in exactly the right position. In some cases it might be necessary to bore new holes in one-half of the coupling, as it is unlikely that the original holes would be found to agree.

These machines have been running in parallel with perfect satisfaction ever since and I believe that this was a very simple way of handling the situation, as practically no special equipment or instruments were needed.

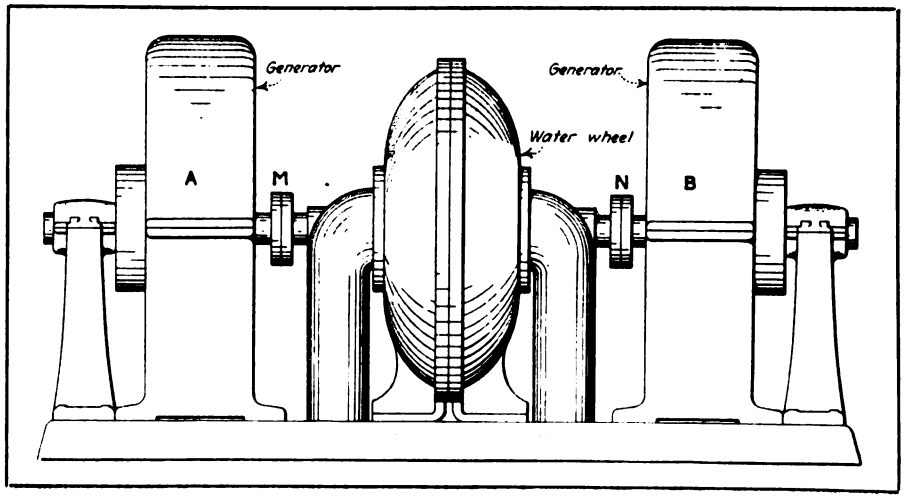
President, R. S. HUNTINGTON.
Huntington & Guerry, Inc.,
Greenville, S. C.

The bolts were removed from the coupling at M and the two halves tied together with string.

Both machines were brought up to speed and paralleled. This operation broke the strings at *M*, but alternator *A* continued running as a motor supplied from alternator *B*. A chalk line was snapped against the coupling *M*, thus marking the position in which the two coupling halves should be bolted together.

Inspection and Testing of Oil for Circuit Breakers

IN a paper on safe operating and inspection practice for circuit breakers and starting devices, presented at the recent Safety Congress, held at Louisville, Ky., G. F. MacWilliams, electrical engineer of the Pennsylvania Coal & Coke Corporation, Cresson, Pa.,



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gave the following interesting information on the inspection of oil switches and the filtering and testing of the oil used in them:

Some oil switches are often required to open circuits carrying currents much larger than those for which the switch is designed. The oil is placed in these switches to prevent an arc being formed when the current is interrupted. These arcs cause carbonization of the oil, which reduces the insulating characteristics and may cause trouble. Dust and dirt also enter the tanks and in many cases form a conducting material.

Whenever an arc is broken under oil the oil dissipates some of this heat and itself becomes heated. This causes an expansion of the oil and a certain quantity of air is expelled from the tank. When the oil cools and contracts, it causes new air to be taken into the tank. If this air contains moisture, which it nearly always does, fine particles of water vapor form on the sides of the tank and drop into the oil.

If much moisture and dirt is permitted to collect in the oil and tank, a heavy arc may cause the switch to explode. Switches of this type with vertical contact boards permit dust and dirt to drop into the tank rather easily, whereas horizontal boards prevent much of the dust from getting into the oil. Dust and dirt collect on the outside of a switch, due to the presence of oil which holds any floating particle of dirt which comes in contact with it. Dust and dirt in this manner form a conductor between the switch terminals and often cause leakage of current to ground or from one line wire to another.

To avoid accidents it is necessary, therefore, to keep the switch as clean as possible and make periodic inspections of all current-carrying parts and also of the oil. Sludge in the bottom of an oil tank may become so deep as to cause current to leak from one of the line wires to ground.

Depending upon the service rendered by an oil switch, the oil should be changed every month or every few years. In dusty, damp places it may be necessary to renew the oil every few months. In clean dry places it may be necessary to renew the oil not oftener than every four years. No set rule can be formulated, as the time will depend on the location and severity of the service. Every oil switch should be inspected at least once a year.

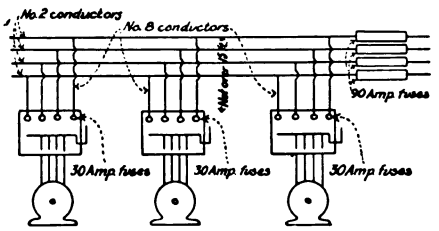
At our mines, unless a switch has been in abnormal service, it is inspected once a year. If moisture or sludge appears in the tank, it is cleaned out, the contacts adjusted and new oil put in. Any oil which appears to be satisfactory is tested before it is used. Oil that appears to be good is often, upon further inspection and test, found to be unsuitable for further use until filtered. For this purpose a filter press is provided.

New or filtered oil must not break down at a voltage less than 35,000 volts when tested between sphere gaps ½-in. in diameter and set 0.15 in. apart. The flash point should not be lower than 171 deg. C and the fire point not less than 178 deg. C.

Accessibility of Fuses Is Big Factor in Laying Out Power Circuits

IT HAS been the accepted custom for years to run a set of mains along the ceiling of a mill or factory and where it is necessary to branch off for a motor, to place a cutout or set of cutouts where the change in size of wire is necessary. At last "the powers that be" are seeing the light and the 1923 National Electrical Code reads as follows:

"Article 8, Section 808, paragraph D. —Automatic overload protective devices may be omitted at the point where conductors carrying the current



Fusing for power circuits where two or more motors are connected to the same mains.

of only one motor are connected to the mains, provided their current-carrying capacity is at least one-third that of the mains and the length of the conductors between the mains and the motor protective devices is not greater than 15 ft. and they are suitably protected from mechanical injury."

At last, under the above conditions, we can get away from the old method of getting a ladder and climbing up among a wilderness of shafting, pipes, belts, and the like, (and probably getting a nice static kick from the belts) simply to renew a fuse in a branch circuit.

From the accompanying diagram the advantage over the old methods of installation will be readily seen. In addition, under these conditions there is a saving of three complete sets of fuses. The life hazard has been eliminated and the troubleman can feel that when a fuse blows it is only a moment's work to replace it.

Time is saved in MAINTENANCE and cost is saved in INSTALLATION. Besides, a much better job is possible from the standpoint of good engineering practice and safety.

EDWIN V. LAMBERT.
Electrical Inspector,
Philadelphia Fire Underwriters' Assoc.,
Ardsley, Pa.

Clean Reflectors Essential for Efficient Lighting

ABOUT the only reason for buying reflectors for overhead industrial lamps is the expectation of saving just about one-half of the light that we know the bulb is producing; approximately half of this goes up, and half goes down. A clean reflector will save pretty nearly all the upward light, while a dirty reflector will not save any. No one has ever found any kind of dirt that will reflect light.

The greatest problem in reflector cleaning is accessibility and when we stop to consider what the reflector cleaner has to do to get at many of the overhead lamps, it is easy to understand how so much money has been lost—wasted—in industrial lighting.

Obviously, the most logical solution of this problem is to make the work easy and safe by installing overhead lamps on a safety lowering switch, operated from the ground by a rope or chain. Then, instead of doing any climbing at all the lamp cleaner pulls the chain, whereupon the lamp is automatically disconnected from the electric circuit and comes down free, and dead. The cleaning is thus done in safety, with convenience and efficiency, down on the ground. When the lamp is pulled up again it goes automatically back into the circuit and locks. This not only eliminates the climbing hazard, but also any electrical hazard, for the lamp cleaner is kept away from the electric circuit.

While the use of a safety lowering switch increases the cost of the installation somewhat, that is exactly true of the reflector, for it also adds to the cost of the installation. The reflector costs more than the bulb and does not produce any light—that is done only by the bulb—and only a clean reflector will save any light. Yet, if anyone today had a plant full of bulbs without reflectors it is reasonable to assume that he would not hesitate to spend whatever amount of money was necessary to put a reflector on every one of those bulbs. Why? He will not be producing any more light than he had before, and unless he keeps the reflectors clean he will not save any light.

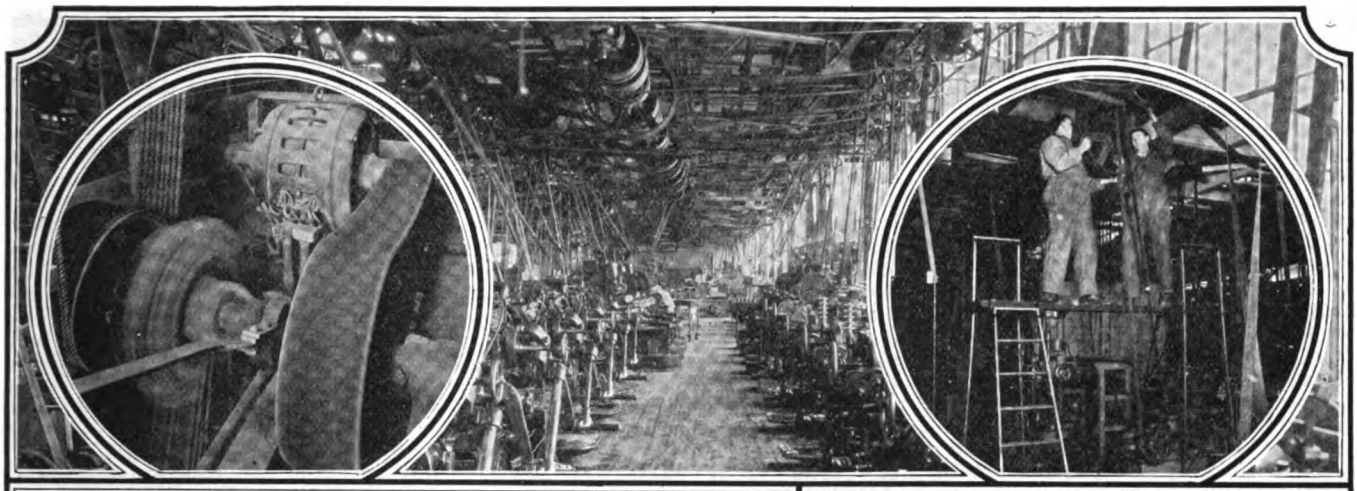
The answer is that the public mind has now become educated to the "idea" of a reflector, just as the public mind has become educated to the idea of conduit, conduit fittings, fuses, etc., all of which add enormously to the cost of the installation, but the only question now is, "What kind?" So, while the safety lowering switch may add something to the cost of the installation, there is no more reason for omitting it than for omitting any other device that may be essential to the proper functioning of the lighting equipment.

If the bulb had been sufficient without the reflector it is a certainty that the reflector manufacturers would never have made any headway with their product. The combination of bulb and reflector will give marvelous results when new—while they are clean and bright and sparkling; but their efficiency falls off with every particle of dirt that accumulates. While it is impossible to prevent the dirt from getting on the lamps, we do not have to let it stay there, although we probably will if the lamp is installed where nobody can do the cleaning without great difficulty or hazard. The modern industrial lighting unit costs too much for merely temporary results, and it is too good a piece of apparatus to be wasted.

It is reasonable, therefore, to add enough to the installation to make it work, and to enable it to give the continuous results of which it is capable.

President, ALLISON J. THOMPSON.
The Thompson Electric Co.,
Cleveland, Ohio.

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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

How to Make a Motor-Driven Crushing Device

BREAKING up old annealing kiln pots was a hard and troublesome job until we constructed the pot crusher which is shown in the illustration. This device has worked so satisfactorily that a description of it may be of interest to readers of INDUSTRIAL ENGINEER who may have use for a machine which will exert a heavy crushing pressure.

As will be seen, the crusher consists essentially of a shaft threaded for a distance of 2½ ft. with a worm screw which passes through a heavy, threaded bearing and is driven forward or backward by a motor through a gear which is keyed to the shaft so that it will turn the latter but allow it to move endwise. Two parallel 8-in. I-beams, 8 ft. long, form the base of the crusher.

The shaft is 6½ ft. long and has cut in it a worm screw of four teeth to the inch for a distance of 2½ ft. at the forward end. The screw portion of the shaft is 2¾ in. in diameter. The remaining 4 ft. of the shaft is 2 7/16 in. in diameter and is smooth. A long keyway ⅝ in. wide and ¼ in. deep is cut in the end of the shaft. A key in the large gear, which is 26 in. in diameter and has 104 teeth, fits loosely enough in the keyway to allow endwise movement of the shaft. The forward end of the shaft is fitted with a hard steel pin 1¼ in. square which is set about 2 in. into the shaft. The forward bearing is 8 in. square and carries a brass sleeve 1 in. thick through which the worm screw on the shaft threads. The rear bearing for the shaft is, of course, plain. Two long 1-in. rods tie the bearings together and serve to equalize the stress on the front bearing.

The shaft is driven by a 15-hp., 60-cycle, three-phase, 1,165-r.p.m., slip-ring General Electric motor whose shaft carries a 3½-in. pinion with fourteen teeth. The motor is mounted at one side of the shaft on two short lengths of channel iron bolted across the I-beam support. With this outfit, we use a General Electric reversible controller, type CR3203, T133B with a type CR3223 resistor.

At full speed, the worm screw advances at the rate of 1 ft. in 18 seconds, and gives enough power to crush in one side of a pot and crack it into two pieces which are then thrown back into the furnace and remelted. These pots are 22 in. square, 12 in. high and 1 in. thick. On cold days this machine will crack the iron pots as fast as two men can handle them, but in warm weather the pots will bend a long way before they will break.

New Britain, Conn. H. S. RICH.

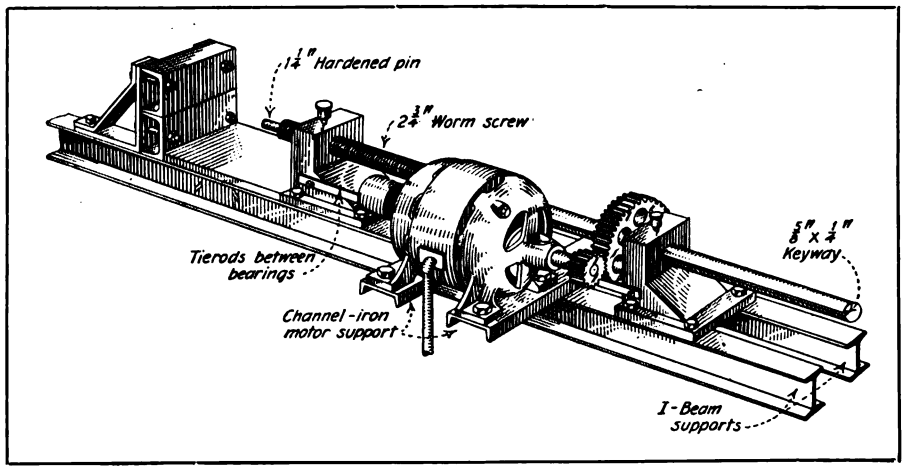
Details of a motor-driven crusher in which the force is applied through a long worm screw.

Construction and Operation of Spur Gear Speed Reducers

SPUR gear speed reducers are totally-enclosed spur-gear drives designed to decrease or step down speeds between electric motors and comparatively slow moving machines. In application they are interposed between the motor and the driven unit. A flexible coupling connects the motor shaft to the high-speed reducer shaft, which is thus driven directly at the motor speed of revolution. Another flexible coupling connects the low-speed shaft of the reducer to the shaft of the driven machine, causing rotation at a relatively low speed. The final speed of the driven machine is governed by the revolutions per minute of the motor, and by the reduction ratio accomplished by the reducer.

Spur gear reducers are most generally made in reduction ratios ranging from 4 to 1 up to 200 to 1, although there are many cases in which smaller or larger ratios are required. Spur gear reducers consist essentially of one or more trains of spur gears assembled in a housing, with provision for oil bath lubrication. They are manufactured in a wide range of standard sizes, horsepower capacities and ratios. The ratio of reduction when once selected is constant; so in this connection they should not be confused with a change-speed box or variable-speed transmission.

The speed reducers fall into two general types so far as internal design is concerned. In one type the high- and low-speed ends are concentric, thus making a straight-line drive. In the other the high- and low-speed shafts



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are not concentric, giving an offset drive. Each style has certain advantages of its own, while many general advantages are common to both. As an example, space conservation in one instance might call for the concentric type, while under different installation conditions the offset type might be found more suitable for the location and as a space saver.

Offset reducers are designed with one or more trains of spur gears assembled in a cast-iron housing in which the housing is split horizontally on the center line of the shaft. The shafts are thus all in the same horizontal plane. The gear assembly is somewhat similar in arrangement to an ordinary open, spur-gear drive.

Inasmuch as each pinion and gear is required to carry the full load at the point of contact where each gear engages, the pitch diameter and face of the gears must be proportioned with this in mind. That is, the gears must be larger and the pitch line velocity greater than if the load were distributed between two or more sets of gears.

The straight-line or concentric drive is entirely different. It consists of one or more trains of spur gears having several points of contact where each train engages. This is done by surrounding a central driving pinion by two, three or more gears equally spaced, the central pinion driving each of the surrounding gears, thus providing separate points of contact for each train.

The assembly is made in a cast-iron housing of circular section with removable heads. The high- and low-speed ends are concentric, and have the same direction of rotation. Due to the total load being distributed among several points of contact, the gears may be designed with a finer pitch, with smaller pitch diameters and consequently with lower peripheral velocities than when single-point contact is used. Also, small gears lend themselves to better accuracy and in manufacturing can be held commercially to closer limits.

Spur gear speed reducers of the types under discussion have been manufactured for about 20 years and probably owe their early popularity if not their actual existence to the cement industry. The atmospheric conditions in cement mills are such that exposed or open gear drives quickly deteriorate, due to the destructive action of the cement dust. The advantages of the enclosed speed reducer apply to other industries even though atmospheric conditions are not so serious.

Economy of space in many instances is also an important consideration. The safety feature, due to its enclosed construction, reduces the accident hazard. Further, the fact that the gears are running in an oil bath, under dustproof conditions, insures positive lubrication at all times with a minimum of attention.

This self-lubrication feature has proved particularly important in obtaining acceptance for the enclosed reducer idea. Totally-enclosed speed reducers running in a bath of oil reduce depreciation and upkeep expense to the minimum in the important department of reducing speeds in power transmission practice.

Since reducers with motors do away to a large extent with pulleys and belts and other space-consuming devices, they do not interfere with the diffusion of light, and help to make the factory more attractive.

The question of initial cost is, of course, an important factor in almost any sale. Although the cost of installing speed reducers varies, it can be said that they are not more expensive than other methods of obtaining reduced speeds when the jobs as installed and ready for operation are compared. It is true that the cost of various units such as gears, belts, ropes and shafting may be lower, but the cost of laying out, assembling, installing and adjusting these various units must be considered. The enclosed reducer has a big advantage in upkeep cost. As the motor and reducer are mounted on a single base and connected to the final drive by a flexible coupling, alignment and bearing troubles are done away with.

A few of the more common applications of speed reducers are on elevators, conveyors, feeders, agitators, mixers, cookers, screens, stokers, tables, fans, dryers, crushers, car hauls, pumps, hoists and gas producers.

Mechanical Engineer, WARREN G. JONES.
W. A. Jones Foundry & Machine Co.,
Chicago, Ill.

Bearing Cost Decreased by Using Steel Pipe in Place of Cast Shell

MANY motors, in particular the railway motor type 12-A and 47-D, use a cast-steel shell. It has been found that a saving of more than $1 per bearing on new bearings for the railway-type motors may be realized by using steel pipe for the shell instead of a steel casting.

It was found that steel castings for bearing shells for the 12-A and 47-D motors cost about $240 per hundred. The cost of 4½-in., XX steel pipe and its cutting runs about $136 for the same number of bearings.

A further saving can be made in the machine work on the steel pipe bearing, for the pipe may be worked faster than the steel castings, which may have sand and hard spots in the surface.

Electrical Engineer. D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

Motor Trouble Traced to Tight Pump Bearings

SOME time ago I was sent to a mine to ascertain the trouble with a centrifugal pump motor. The only information given by the master mechanic at the mine was that the motor would not come up to its proper speed under load. He did not state whether the motor was direct or alternating current. Accordingly I collected a miscellaneous supply of material and tools and departed for the mine.

Upon arriving there I found the pump to be a horizontal type, direct connected to a self-starting a.c. motor running at 1,800 r.p.m. The mine mechanics had already disassembled the motor and had the rotor out of the stator. I carefully examined the stator for burned coils and tested it for shorts, opens and grounds. After failing to find the trouble there, I turned to the rotor which was of a type unusual in this part of the country (Alabama). The motor was manufactured by the Century Electric Company, and was a 60-hp., three-phase, 220-volt 60-cycle design. It was self-starting; that is to start it, the switch was thrown to the closed position and the motor accelerated automatically by a centrifugal arrangement commonly used on single-phase motors. The rotor had two windings. One was just a plain induction rotor winding, while the other was wound and connected to a disc commutator as in the ordinary single-phase motor. This commutator was not equipped with brushes, however, but had a fan which was screwed up on the spring and contact mechanism, acting as a nut. The fan was locked in position by a key. It also had a felt washer on the inside face to prevent oil from entering the contact receptacle.

I removed the locking key and fan, counting the number of threads in order to know just where to replace it. The shell for the centrifugal contacts was found to be broken and one piece had worked loose. This loose piece was, I judge, the direct cause of the machine not attaining speed as it probably bound the other parts of the shell or the spring. Realizing that it was best to make a sure repair, I loaded the rotor on a truck and carried it to the repair shop, where the machinists duplicated the shell. The rotor bands were resoldered, and also the commutator.

While examining the rotor in the shop it was found that one of the rods or plungers that actuated the contact mechanism, was longer than the other. The short rod had worn from some cause. This rod was heated and drawn out to equal the length of the longer rod. I believe that this short rod in closing the centrifugal switch did not exert equal pressure on the shell, thereby causing one side of the shell to move behind the other and in this way have a tendency to crush the contact shell, which was constructed of cast iron.

The rotor was returned to the pump and the motor reassembled. It ran finely without load. The coupling was bolted up and the switch thrown in, but the motor would not pick up. The adjusting nut or fan was loosened a turn or two and the motor again assembled, but it would not start. The coupling bolts were then removed so as to disconnect the motor from the pump and the motor started fine.

From this it was evident that the trouble was in the pump, which had been overhauled while the motor was down. All the bearing caps, including the thrust bearing, were loosened and the motor reconnected to the pump. It then ran nicely. It was operated against a 130-lb. pressure for 30 min. and was then shut down and examined for heating. With everything apparently all right the motor was started several times with the load, in order to be sure it was O. K.

Birmingham, Ala. GRADY H. EMERSON.

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This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Working Out a Change in Winding of an Induction Motor

THE following details describe a change made in an induction motor that was brought in for repairs and indicates how a live coil man can save considerable time and money by taking all points into consideration when repairing motors.

The job in question was a 50-hp., 850-r.p.m., 220-volt, 60-cycle, three-phase, squirrel-cage induction motor, used to drive a ventilating fan in a large factory. The application required that the motor operate at its full rated load, 18 hr. a day. The air passing the motor was from a drying room, which kept the motor quite hot. The job was a day-and-night proposition, and the customer asked us to give it all the copper we could.

The winding data was 72 slots and coils; the coils were 2-layer, diamond-mould wound, each coil consisting of eight turns of three No. 17 d.c.c. wires in parallel with a formation of three wide by three deep. This was an old type of coil that was composed of three single coils; that is 216 single coils of eight turns of one No. 17 wire were wound to shape on a mould and these three coils were assembled to make one complete coil. The pitch was 1-and-9, and the coils were connected 4-parallel star, for 220 volts.

We first decided to make the coil a puller type, that is, wound on a shuttle complete and then pulled to shape. It was next decided to try to use a ribbon wire instead of three No. 17 wires. On consulting a wire table it was found that No. 17 wire has a bare diameter of 0.0453 in. So that the size ribbon required would be 0.0453 by $(3 \times 0.0453) = 0.0453$ by 0.1359 in. One No. 17 wire has an area of 2,048 circ. mil, and three an area of $3 \times 2,048 = 6,144$ circ. mil. On consulting a ribbon wire table we found an 0.0453 in. by 0.145 in. bare ribbon, with an area of 7,804 circ. mil. The increase in cross sectional area was due to less cotton and the filling in the space between circles with copper. We then could make a coil with eight turns of one 0.453 in. by 0.145 in. d.c.c ribbon, but we decided to check further to see if the turns per coil could be reduced to four, using a 2-parallel star connection, which would give the same turns per phase as an 8-turn coil and a 4-parallel connection.

By using four turns this would mean a conductor of twice the cross section, or 0.0906 in. by 0.145 in. On looking in the ribbon wire table, we found an 0.092 in. by 0.145 in. ribbon wire with an area of 16,972 circ. mil. Checking the insulated sizes, No. 17 d.c.c. wire has an insulated diameter of 0.054 in.; then the room taken up in the slot, width-wise, by three No. 17 d.c.c. wires would be $3 \times 0.054 = 0.162$ in., and two No. 17 d.c.c. equal 2×0.054 or 0.108 in. The insulated size of the 0.092 in. by 0.154 in. d.c.c. ribbon wire would be 0.109 in. by 0.167 in., which is close enough to the 2 by 3, No. 17 d.c.c. wire size. By replacing six No. 17 wires with one ribbon wire the circ. mil area had been increased from $6 \times 2,048 = 12,288$ circ. mil to 16,972 circ. mil, or an increase of 38 per cent in copper. Also this made a better coil from a mechanical standpoint and reduced the turns from eight to four, reducing by more than one-half the time required to wind the coils.

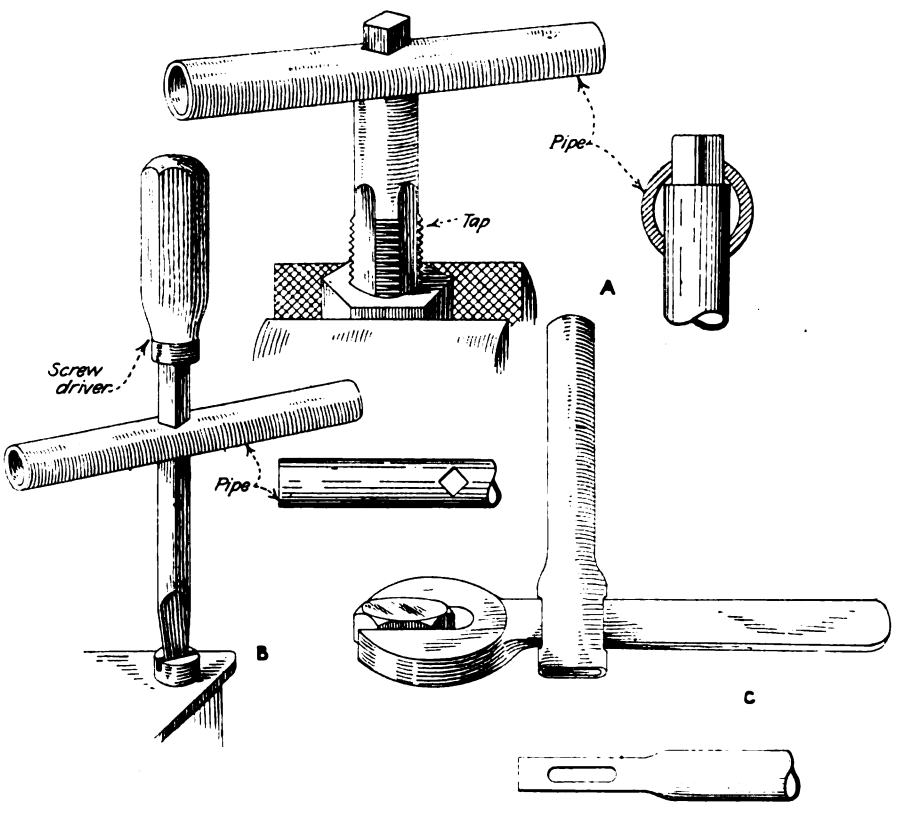
From the above it follows that it pays to investigate each job from A to Z for time-saving and improvement factors.

Wilkinsburg, Pa. A. C. ROE.

Simple Devices That Are Handy as Wrench and Tool Handles

IN SHOP work wrenches and handles to serve specific purposes are not always available. The monkey wrench is invariably called into use to help out in turning some tools. However, this is not a handy tool to use in conjunction with other tools. Several con-

Three types of wrench and tool handles that help out in tight places.



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venient devices that are handy for such uses are shown in the accompanying illustration.

The first of these, (A), is a wrench for a reamer or taps, that is made up from wrought-iron pipe. This is readily made, holds the tap or reamer squarely and affords good working grips.

The second tool, (B), is a handle for the usual square type of screwdriver, and is useful in the removal or setting up of tight machine screws. The handle is a short length of pipe, squared out for the blade of the tool, as shown.

The third tool, (C), is an auxiliary handle for an open-end wrench, and is similarly made from pipe. The end is flattened and slotted to slide over the wrench handle, as shown. With this extra handle, the user works to an advantage in that both hands are used on the tool, when the bolt resists turning with the usual handle of the open-end wrench.

Washington, D. C. G. A. LUERS.

How a 750-Hp. Motor Was Banded Under Difficulty

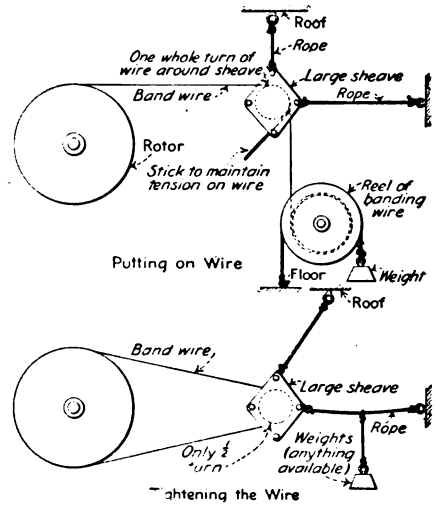
ONE of the hardest jobs I was ever called upon to do was banding the rotor of a motor driving a 20-in. centrifugal pump on a suction dredger. This was a 750-hp., wound-rotor 2200-volt, three-phase, 350-r.p.m. motor and was direct connected to the pump by means of a flexible coupling. In order to make clear the difficulty under which we worked it may be well to explain that the motor base was on 12-in. channel iron which was used for bracing the flat bottom of the steel hull of the dredger. A steel beam 4 ft. high and also used for bracing ran from fore to aft through the center of the dredger. The operating platform was about 4 ft. higher than the shaft of the motor and was cut out around the motor to allow the operator room.

When rotor trouble developed, it was necessary to tear out about 2 ft. of the operator's platform. The stator was jacked over as far as it would go or until it struck the beam running fore and aft and the rotor was pulled out until it was 8 in. from the remaining part of the platform, or just enough to allow arm room for a man to handle a heavy soldering iron, which was best heated in a forge on the job.

The rotor was then slightly more than half-way out of the stator frame, with blocking at one end holding up the rotor in the stator. Two blocks with semi-circular slots slightly larger than the rotor shaft, and well greased, served as bearings for the rotor during the progress of the work. These bearing blocks were placed in position during the final reblocking, so as to allow for proper clearance of the rotor as it was rotated in the frame. The blocking was well braced, to avoid any possibility of upsetting due to rocking of the dredger, and to maintain the proper clearance against the eccentric pull of the band wire and rope drive.

When all of the electrical trouble was cleared up, there came the problem of banding this rotor which was 7 ft. in diameter, and this was accomplished as shown in the illustration.

A 2-in. hawser was given a full turn around the winch of the dredger, spliced with a long splice to make it continuous, then passed around the rotor. Another large sheave with weights attached to it was used as an idler for this improvised rope drive. By this arrangement we were able to use the winch for turning the rotor while the band wire was put on.



The band wire was first put under light tension and then tightened.

After the desired width of band was obtained, the wire was cut, given one-half turn around the sheave wheel and the loose end fastened to the rotor. By turning the rotor in the opposite direction, the band was rewound to one side of its original position and by hanging a weight on the rope attached to the side of the sheave, the tension of the wire was increased while it was being rewound. The rotor was again turned in the opposite direction (this time in the original direction), the tension further increased by hanging more weight on the rope and the band rewound to the desired position under heavy tension.

The banding wire was put on as shown in the upper portion of the illustration. Another large sheave was fastened in the position shown. A complete turn of banding wire was put around the 2 ft. wheel of the sheave and the end fastened to the rotor. The housing of the sheave is separated from the wheel by four pins. One of the helpers held a hardwood stick against one of the pins and against the wheel and thus maintained a fairly good tension on the wire when it was first wound on, as far as was possible with the rotor in its first position.

The rigging was then changed as shown in the lower part of the illustration. The band wire was cut, given a one-half turn around the wheel of the sheave and the loose end fastened on the rotor. Weights were then placed on the rope holding the sheave, thus putting the wire under tension. The winch was reversed, driving the rotor in the opposite direction and the band wire wound tighter. When the end was reached, more weights were put on the rope and the winch again reversed, or run in the same direction as at first and the wire wound as tight as was desired, and the bands then soldered.

By winding the wire on in this manner the slack was automatically taken up and we could have put the wire under sufficient tension to pull it in two, if we had so desired.

It was possible, of course, to band only one-half of the rotor at a time. When this one end was finished, it was necessary to shove the rotor through to the other side and put the stator frame back where the rotor was. Altogether it was a long and hard job but by the exercise of a little ingenuity, we were able to do it satisfactorily under conditions which seemed at first sight to be almost hopeless.

Oakland, Calif. S. H. SAMUELS

An Emergency Repair That Insured Protection Against Field Breakdowns

THE writer has had occasion several times to repair or put into operation a Type C direct-current, Westinghouse automatic planer control used on a Betts planer. This installation was one of those wartime "temporary installations" which has not been changed to permanent. It is, however, wired correctly and gives good service with very few interruptions—but when there is an interruption it calls for a "good hunting" expedition.

One of the worst service interruptions on this installation was caused by a spark jumping from a shunt field lead to the series field lead, which is uninsulated. The shunt field lead had a very small rupture in its insulation, and this worn place was in the top of the motor, so that the spark could not well be observed and was not noticed at the time of the trouble.

The sparking occurred at the reversal of the motor after the planer had made a cut and was about to return, when the load was heavy, likewise the current. This induced the high voltage required for the jump spark. The other effects were to slow down the motor on return and cause a slight arc at the brushes momentarily, with a severe arc across the butterfly reversing contacts. When this latter arc was blown out by a puff of air, the motor would speed up, and as all connections checked with the blueprint, and it was rather late at night when I had made all tests possible with the instruments available, I decided to place a shunt magnet coil wound for 230 volts direct current directly above the butterfiy contacts to blow out the arc formed at the reversal of the motor. This magnet was so wired that it would be in circuit when the operating circuit was closed.

The main thing was to get the planer to operating satisfactorily and this was accordingly done. I would like to state that the scheme worked admirably. This installation has given very little trouble since this change was made.

Later a very careful inspection on overhauling revealed the small break in the insulation on the shunt field lead which I believe was the cause of the trouble, but the blow-out coil has not been removed and probably never will be, as it will answer as an additional protection in the future.

Birmingham, Ala. GRADY H. EMERSON.

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How to Change Direction of Winding Armature Without Changing Rotation

MANY small armatures are wound by machine so that the armature is turned end-for-end in a right-hand direction while the wire is guided in the slot as the armature revolves. The wire is really wound on in a left-hand direction. We do not use a machine for winding small armatures in our shop but do them all by hand, holding them in the left hand and winding the wire on with the right hand. Many winders find it easier to put the wire on in a clockwise direction and so they do it that way, even though it was originally wound counter-clockwise, but when the motor is assembled the armature runs in the wrong direction. To those who have experienced this trouble, let me say that when you change the direction of winding, you should also change the direction of the progression of the winding.

For example, assume that an armature is wound left-hand or counter-clockwise with the winding progressing from slot to slot in a right-hand direction. If desired, this armature may be wound right-handed with the winding progressing to the left. If it is wound left-hand, progressing to the left, change it to right-hand, progressing to the right. It is only natural to suppose that if the winder is a man who uses his left hand to wind the wire on, the above rules will work vice versa.

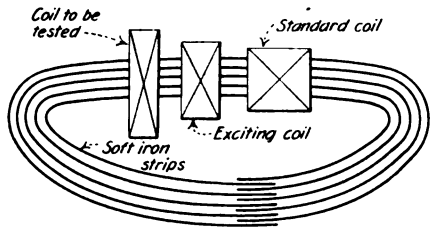
Darby, Pa. GEORGE WM. HANLON.

How to Determine The Number of Turns in a Coil Without Opening It

WHEN doing repair or experimental work on electrical apparatus, it very often happens that a duplicate of a certain coil is wanted without opening or destroying the sample coil. The question then comes up as to how many turns are on the coil and what size of wire was used in winding it. Of course, nearly all coils wound in factories have a code number on them so that one need only send in the code number of the coil to obtain the new one from the manufacturer. However, it often happens that the duplicate coil must be had immediately, or that the code number has been lost, so that no identification of the coil is possible. In this case, about the only thing for the average electrician to do is to tear the sample coil to pieces and see what is in it.

If a coil with a known number of turns can be obtained, that is approximately like the coil with the unknown number of turns, it is possible by a simple test to determine the number of turns in the sample coil. Recently I had just such a case to deal with in a coil used on a lifting magnet. I was told how many turns were in the old coil which was still good and which I wished to save for further use. When I had completed the new coil, it did not lift as much as the old one. I tested it as described below and discovered that the old coil had about fifty turns less than it was thought to have. I therefore took off fifty turns from the new coil, after which it worked the same as the old one.

In the accompanying diagram is shown the arrangement of the magnetic circuit by means of which the two coils were compared. Soft sheet iron strips are passed through the centers of the standard coil (which is wound with a known number of turns), the coil to be tested (wound with an unknown number of turns) and an exciting coil, which is to furnish the magnetic flux for the circuit. The exciting coil can be almost any kind of a coil that will fit over the soft iron strips. It must be placed in the center of the magnetic circuit as shown in the diagram and is excited with alternating current. Care should be taken not to over-excite or saturate the iron, so as to keep down the magnetic leakage. The ends of the soft iron strips should be clamped together after being passed through the coil, so as to reduce the reluctance of the magnetic circuit as much as possible.



The voltage induced by the sample coil is compared with that induced by a coil with a known number of turns when both are placed in the same magnetic circuit, which is excited by an exciting coil.

Knowing the number of turns in the standard coil and the induced voltages in both coils, the number of turns in the coil under test may be calculated by means of the formula given in the text.

The two coils that are to be compared are placed one on each side of the exciting coil as shown in the diagram, with the center of each coil at the same distance from the exciting coil. If both coils are alike, they should be placed as near to the exciting coil as possible but if one is wider than the other, a little allowance should be made as shown in the diagram, which shows such a condition. The voltage induced in the standard coil and in the coil under test is measured with a voltmeter while the exciting coil is furnishing the flux to excite the two coils. The number of turns of the coil under test may be determined by means of the following formula:

$$N1 \div N2 = E1 \div E2,$$

where

N1 = number of turns on standard coil,
N2 = number of turns on coil under test,
E1 = voltage across standard coil, and
E2 = voltage across coil under test.

After the number of turns on a coil are known it is a simple matter to estimate the length of wire on the coil and if the resistance of the coil can be measured, it is very easy to figure the size of wire.

In making such a test, a little care should be taken, especially if the two coils are not alike in size or shape, because magnetic leakage may affect the result. That is, if one coil is thin while the other is a thick coil, the center of each must be in the same relative position on the core; otherwise the diameter or shape of the coils need not be alike. In fact, the size of the coil, or the size of the wire in the coil, make little difference as long as the same number of lines of force or magnetic flux pass through both the standard coil and the coil with the unknown number of turns. It is important therefore, to properly arrange the magnetic circuit so as to get an equal amount of flux through each coil. To check the result, the tests should be repeated after interchanging the positions of the standard coil and the coil with the unknown number of turns.

PHILLIP G. BERNHOLZ.

East Orange, N. J.

Making Patterns and Molds From Plaster of Paris

OCCASIONALLY it is desired to mold small parts in lead, brass, or cast iron and it may be necessary to make up a pattern or mold quickly with the equipment and materials available. For such use serviceable patterns and molds can be made from plaster of paris, as this material hardens rapidly and dries out readily. If desired, the hardening can be delayed somewhat by the addition of a small quantity of vinegar when mixing up the plaster.

When preparing the plaster care should be taken to mix it thoroughly, preferably by hand, to insure that all lumps are broken up.

If the broken part or a spare is available a mold can be made by placing the part on a smooth, flat board or iron plate, and enclosing it in a tight box or frame open at the top. The part, as well as the box, should be well greased or oiled to keep the plaster from sticking. As soon as the plaster has set, the frame should be taken apart and the pattern removed from the mold. It is advisable to allow the latter to dry overnight in a warm place and it should be washed with graphite wash or other refractory material before pouring the casting.

If a plaster pattern is used it should be kept from sticking to the mold or absorbing moisture by coating it with paraffine wax, either by dipping it in melted paraffine or applying this with a brush. Paraffine can also be used to keep the halves of a two-part flask from sticking together.

When making either patterns or molds, thin wire and nails are desirable as reinforcing material in the plaster. If it is desired to increase the bulk of the plaster of paris, thus avoiding extra expense, clean, sharp building sand may be stirred into it before pouring.

Washington, D. C. G. A. LUERS.

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Reducing Accidents and Breakdowns

(*Continued from page 122*)

of course, was immediately covered. It is just one example of the unanticipated accidents against which we must always be on our guard.

In promoting safety work, we have adopted the committee form of safety organization. Safety pays according to the increased number who become interested in it and adopt it, and also because of having served on a committee a larger number of men, who are intimately connected with the plant and its activities, are making suggestions and pointing out new hazards and how they may be overcome. This organization consists of one safety director or engineer, who devotes his whole time to safety and personnel work and four different committees, each meeting monthly on consecutive Thursdays.

The first meeting is made up of a committee of the men chosen by the men themselves; the second consists of foremen; the third is made up of men appointed from the various departments by their foremen; the fourth committee consists of the three general foremen and three others. The safety director acts as secretary of these committees, records suggestions and recommendations, investigates between meetings and reports on them to the next committee. Action is reported back to the committees instigating and passing on the idea. This secretary keeps a record of each action of any of these committees until its adoption or rejection.

This does not mean that every suggestion takes four weeks to be acted upon. Small matters are handled quickly by reporting them directly to the mechanical department which carries them out and reports back. Items which will probably cost over $25, must, however, bear the approval of the superintendent. Emergencies are also handled without going through committee routine. It must be understood that the purpose of these committees is to bring out more ideas and add to the interest of the men. This cannot be obtained without letting them see results. Not all suggestions, however, are used as adopted, because many of them are crude ideas which can be greatly improved upon by the mechanical department when they take hold of them.

Another important part of the safety work is giving publicity to accidents and hazardous conditions, especially those which result from carelessness. We found that one of the best ways of getting this over to the men was by means of bulletins made from photographs of the hazardous condition or especially posed to show how the accident happened. This is not as easy as it may seem because a great amount of care and diplomacy must be exercised to prevent getting the ill-will and opposition, instead of the respect and co-operation, of the men. For this reason we do not mention who was responsible for the condition photographed and, if it was especially posed, we give the man in the picture credit for knowing better so that he will not be "kidded" by the others. Four of these bulletins are reproduced on page 120 as we used them. The text accompanying each illustration is set in our print shop.

On one occasion an outside millwright gang which was doing some construction and installation work on contract gave us an opportunity to take a number of photographs which showed carelessness, but did not reflect on our own men, although it caused them to be more careful. One of these pictures showed an opening cut through the floor in a passageway and left overnight unguarded by barriers or signs while the gang was away. Another showed boards with nails left lying around. Still another was of an accident which resulted from men carrying a long pipe and leaning one end against a roll of paper standing on end. The roll tipped and broke a man's leg. Other pictures showed men carrying tools and even a mop and pail up a belt man-elevator which we have installed to carry the supervisory force between floors. Incidentally, one of the safety suggestions brought out the need of an automatic stop to prevent anyone riding past the top floor and being dumped over the top.

The camera, however, is not used as much now as at first because we do not find as much to photograph. These photographs make excellent bulletins as they are right at home and impress upon all the cause and effect of an accident which most of them have heard of and know the principals.

In promoting the safety work considerable attention was given to interesting the mechanical and electrical men responsible for the maintenance and operation of the equipment, because much of the success or failure of safety education depends upon the example and attitude of these men. The general foremen in charge of these men were very enthusiastic in their co-operation. One of the rules made was that the men should clean up after every job. While this is good housekeeping it helped in safety by promoting pride in the work and feelings of thoughtfulness and carefulness. Poor housekeeping destroys pride and also makes many accidents possible.

Altogether we are quite well satisfied with the progress of our safety work, but must keep continually at it to see that the interest of the men is sustained. Safety work cannot stand still; it must progress or interest will lag and accidents increase.



Starting equipment and panel boards for four flaking rolls and the compensator for two groups of motors.

Since only one motor of a group is to be started at a time, a single G. E. CR-1034, Type NR compensator is connected to the line for each two groups of motors and their panel board. A G. E. barrel switch with the compensator coils removed and overload relay mounted in their place is used for the actual starting. This not only affects a considerable saving in the installation cost, but it permits of starting the machines in any sequence. The only restriction is that only one mill in a group can be started at a time.

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Requirements of Safety Switches

(*Continued from page 126*)

(9) The door should be locked when the switch is in the closed position, but it should be possible to unlatch the door by means of a screwdriver for inspection. It should not be possible to throw the switch in until the cover is closed and latched.

(10) The door of the switchbox should, when open, expose the interior of the box completely, permitting ready inspection and access to both line and motor leads for convenience in testing.

The open type of distribution switch panel with busbars, fuses and switches mounted on the face of a marble or slate panel has long been a source of danger and trouble. The fuses were usually on the circuit- or the line-side of the switch. Tools would often fall onto the bus mounted on the lower part of the panel and danger accompanied the handling of large fuses while live. From the standpoint of design of a distribution system this panel represented a very inflexible unit because the bus could not be reinforced and additional circuits could not be added when the load increased unexpectedly, as is usually the case in a growing industrial plant. During 1918 in view of the success attending the use of safety switches for motor drives, the writer installed the type of distribution panel shown in Fig. 3 in which use is made of a pipe rack with busbars running along the top of the rack and supported on pipe-mounted bus insulators. Details of a typical panel are shown in Fig. 2. Standard enclosed safety switches of 400- and 600-amp. capacity were mounted on panels supported on the pipe framework. The circuits were divided, the number of circuits being determined by two requirements; first, the metering necessary and, second, that no circuit should be loaded beyond the capacity of a 600-amp. switch. This follows because above 600-amp. fuses must be installed in multiple, and multiple fuses are altogether incompatible with continuity of service. Whenever the load increases a 600-amp. switch may be substituted for a 400-amp. switch, or where a 600-amp. switch is already installed a section of bus may be put in with a new circuit to provide for the additional load. As for the additional cost of the construction, this switchrack is about double the cost of the old panel itself. The remainder of the wiring cost remains the same. The additional cost is, however, a very small percentage of the total wiring cost. The switches are protected from dust by the enclosing box and when high humidity conditions are encountered the distribution structure should be enclosed in a fireproof housing which will practically eliminate condensed moisture and attending corrosion. Metering may be easily accomplished by using switchboard-type current transformers mounted in the leads between the bus and the switches, or a bus-type transformer may be inserted at the feed end of the bus to meter the entire distribution center, if it supplies a single department.

Reminiscences of a Trouble Shooter

(*Continued from page 132*)

"Right now there comes the recollection of another trip, an inspection trip to repair waterwheel generators, large in capacity and size. A little 'shrimp' met me at the station, and took me to his home for lunch, where a predominant and varnished wife dictated to her lord and master a few things that make men go to war for peace. In using the word 'varnished' I mean to imply the kind that is 'dear this' and 'honey that,' while at the same time probably stepping on his toes or kicking him under the table to get an answer in accordance with her wishes. This ordeal completed, we adjourned to the station. It was a magnificent place with modern machinery, and was a fine monument to some engineer. The machines were polished and clean, the switchboard in good condition, brass all shined up and, in general, the place presented a very good appearance. This station had been in continuous operation for about ten years and it was desired to show that the manufacturer should pay a proportionate part of a general repair expense.

"An inspection of the main generators was sufficient to tell the inspector a whole volume. Coils were actually clogged with dirt at points where a hurried cleaning at a date not very long preceding my visit had reached the surface dirt, but not the dirt that a competent man can find. Furthermore, this dirt was of a pure oil nature, the source of which was leaky oil pipes and bearings at every possible point that oil could get out. The bearings were 'shot'; some had clearances that made one feel in danger, knowing what consequences might result. The lower bearing of lignum vitae was in such bad shape on one of the wheels that the runners touched the casing at every revolution, imparting a decided shock to the entire machine. The oil in all the bearings was in poor condition, although the chief said it was changed often enough to insure good oil. His trouble was in his filter system, which was so dirty that good oil would come out contaminated. His switchboard looked good, but some of his meters were out of commission, although the company had a meter department. One of his current transformers was in commission with the meter removed and the secondary open. His Tirrell regulator was erratic, but a hundred or more fish flies in the oil chamber will make anything erratic.

"Behind the scenes in this inspection we found the chief at a fine desk so cluttered up with everything that the insides were hardly visible. He had been with the company three or four years. He had seven operators with a four-hour shift himself in operating. None of the operators had been with the company two years, while most of them had their first year to complete. Notices on the board assigning work were written in longhand by the chief and many misspelled words were apparent. Unfortunately, another notice on the board, from the superintendent, stated that the machines had to be cleaned up at a date just prior to my visit. A talk with the operators disclosed that trouble with men was a continuous thing, since the chief was ignorant of his work and more ignorant of his men. One faction was always led by the chief while the other faction was led by—well, let us call them the other side.

"It is regrettable that good machinery should be put in the care of such men, ignorant of themselves, of others, of their profession, possibly underpaid and merely holding their jobs. Think of the ultimate cost of these men! To go on with further details is needless. There is only one kind of a report to make under these conditions. It is, however, in order to remark (and I wish this remark would bore a deep hole into the consciences of those who need it) that the inspecting engineer bases his report on a great many conditions aside from those he finds in the ma-

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chinery. Contributory elements either credit or discredit what he finds in a plant, based on his engineering ability and a good understanding of what to look for and where to find the little details that tell a whole story to him.

"That little squeak that the operator is used to, that little oil leak that does no apparent harm, the kind of housekeeping, the types of men employed, their loyalty and knowledge of themselves, the company and their work, are factors that tell an operating story in themselves.

"And, now I want to say something else," Ed went on, "that you can pass on to the readers of INDUSTRIAL ENGINEER. Good or bad operating conditions in men or machines cannot be effected over night; when conditions are good, you may be sure that they are the results of eternal vigilance by loyal workers who know their work and take pride in doing it to the best of their ability. Such interest and work are reflected within and without in the machinery, and in the earnings that make a plant a paying proposition and a place of engineering beauty, alike, to the experienced and the inexperienced visitor.

"Just ask your readers for me if their plants will stand an inspection tomorrow."

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Practical Calculus for Home Study—By Claude Irwin Palmer. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City, 435 pages, $3.

This book is prepared for those men without college training who desire a working knowledge of the calculus and its practical applications. For those who have a groundwork in algebra this book provides a means of understanding and making use of calculus in design work.

* * * *

Natural Gas—By Lester Clyde Lichty. Published by John Wiley & Sons, New York City, 516 pages, $7.50.

This book deals with the measurement, compression and transmission of natural gas and presents various technical formulas and details of equipment employed. In many cases examples have been worked out illustrating the use of various formulas and charts as a guide in solving a variety of problems encountered in the use of natural gas.

* * * *

Elements of Electrical Engineering—By George D. Shepardson. Published by The Macmillan Co., New York City, 326 pages, illustrated, price $4.

In the preface of this book the author states that it was written as a textbook on electrical engineering for technical schools and colleges. It includes a brief discussion of fundamental and operating principles of important types of direct- and alternating-current machines. The treatment is semi-technical with sufficient illustrations to point out the practical applications of the principles discussed. The chapter headings are as follows: effects and varieties of electricity; units; the flow of current through a circuit; typical electric circuits; electro-magnetism; electromagnetic mechanisms; measurement of current and voltage; dielectric phenomena; insulation; conductor materials; wires; measurement of resistance; relations between heat and electricity; electrochemical effects; primary batteries; storage batteries; induced electromotive forces; alternating currents; electric motors; and transmission and distribution systems.

* * * *

Choosing Your Life Work—By William Rosengarten. Published by McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City, 318 pages, price $2.50.

The object of this book is to present in plain and non-technical language a simple and effective plan whereby the individual may analyze his own capacities, aptitudes and interests, compare them with the requirements of representative occupations, and plan his career accordingly. Hundreds of occupations, trades, callings and professions are described and analyzed.

* * * *

Arc Welding and Cutting Manual—Compiled and distributed by General Electric Company, Schenectady, N. Y., 127 pages, illustrated, price $1.00.

This volume has been given the designation Y-2007 and was issued to acquaint the uninformed in a general way with the common applications of arc welding, and to provide a simple and logical method by which one may acquire a certain familiarity with the characteristics and manipulation of the electric welding arc. The volume is profusely illustrated with photographs, diagrams and charts, explanatory of the text on 8-in. by 10½-in. pages. It is divided into three parts, the first of which is devoted to general information on arc welding, the second to a training course for operators and the third gives a number of applications of arc welding. This manual should prove valuable to any operator or anyone who wishes to become an operator and do the miscellaneous work required in practically all industries and trades.

Electric Wiring—By Albert A. Schuhler. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City, 249 pages, price $2.50.

This book was written as a textbook on applied electricity for vocational and trade schools and such material has been used as will enable the reader to understand the principles involved in electrical wiring. Electrical construction details are not included. The material is divided into units corresponding to chapters in the usual book construction, dealing with the following subjects: splicing and soldering conductors; bell wiring; annunciator wiring; burglar alarm wiring; electric light wiring; house wiring plans; telegraph wiring; telephone wiring and testing. Numerous diagrams are used to illustrate the principles that are discussed.

* * * *

Storage Batteries—By George Wood Vinal. Published by John Wiley & Sons, Inc., New York City, 394 pages, price $4.50.

This book presents a rather technical discussion on the construction and principles of operation of the storage battery. Under the heading of "Operation," methods of charging and details of charging equipment are taken up. A section is devoted to operating conditions, cost of operation and sources of trouble. A chapter is also devoted to testing storage batteries and one to present-day uses of storage batteries. The author is physicist with the Bureau of Standards and states that he was encouraged to undertake preparation of the book by Dr. S. W. Stratton, formerly Director of the Bureau of Standards and by Dr. E. B. Rosa, chief physicist. It is a well-rounded discussion on storage batteries from a technical standpoint.

* * * *

Tulley's Handbook in Three Volumes—Revised and enlarged by James F. Hobart, 7th edition. Published by the McGraw-Hill Book Co., 370 Seventh Ave., New York City, 1156 pages, price $7.50.

Volume 1 is devoted to the steam plant and covers steam boilers; chimneys; furnaces and stokers; fuels; coal handling and ash disposal; chimney gas analysis; combustion control; damper regulation; steam boiler evaporation tests; economizers; superheaters; feedwater heaters; filters; traps and separators; and condensers.

Volume 2 is devoted to pumps; injectors; inspirators; gages and recording instruments; valves; fittings; appliances; reciprocating engines; steam turbines; indicators and their uses; engine safety stops; tachometers; governors; pulleys, belts and gears; power transmission.

Volume 3 is devoted to d.c. generators and motors; a.c. generators and motors; lamps; circuits; transformers; mechanical refrigeration; ice-making; elevators; meters for water, steam, air, gas and coal; air compressors; heating and ventilating; internal combustion engines; and handy reference tables.

This is the seventh edition of this handbook which for nearly 25 years has been used by thousands of power plant men in their daily work. It contains practical information and a common-sense viewpoint that makes it a very useful reference for a practical man.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Rockbestos Products Corporation, New Haven, Conn.—A 32-page booklet entitled, "Asbestos-Covered Wires and Cables for Every Service," has a number of handsome illustrations which show some of the tests applied to the Rockbestos insulation. In addition, the various types of Rockbestos protected wire for various commercial and industrial purposes are described.

Holophane Glass Company, Inc., 342 Madison Avenue, New York City—A 20-page booklet, Bulletin 394 entitled, "Holophane Industrial Lighting," contains a number of photographs of typical installations and shows some special application in a variety of industries. The characteristics of each of the industrial lighting units are illustrated and described and light distribution curves are plotted. Items of particular interest are "before" and "after" illustrations taken in a steel mill.

General Electric Company, Schenectady, N. Y.—A 12-page illustrated and descriptive bulletin, Y-2041, entitled, "Voltage Drop Control System," takes up, among other points, a discussion of: What is voltage drop control? What extraordinary thing does it do? Can I use it in any of my work? Is it worth while for me to adopt it?

Standard Conveyor Company, North St. Paul, Minn.—Catalog 3, which is the third of a series entitled "Wherever Conveying Is Done," shows by a large number of installations some of the variety of industrial applications which can be made of Standard conveyors, pneumatic tubes, stackers and portable piling equipment.

New England Sales and Engineering Company, Worcester, Mass.—Folders describe the Notadent soft metal hammer which is made in 3-, 5- and 8-lb. weights in babbitt and 2¼-, 4- and 5½-lb. weights in bronze.

Birdsboro Steel Foundry and Machine Company, Birdsboro, Berks County, Pa.—A folder describes the Jackson belt lacer which is a special machine for lacing belts. With this a continuous wire forms a series of loops in the end of the belt. These loops in the two ends are joined by a rawhide pin which forms a hinge. The booklet also contains considerable belt and pulley data.

Crane Puller Company, 54 Lake Street, Arlington, Mass.—A folder describes the Crane wheel and gear puller which is made in four sizes to take wheels from 6 in. up to 24 in. in diameter. It is made as either a two-arm or a three-arm "crowfoot" puller. This puller has attachments which enable it to be used as an arbor press, for bending pipe and on heavy truck wheels.

W. A. Jones Foundry and Machine Company, 4430 West Roosevelt Road, Chicago, Ill.—General Catalog 30 covers the complete line of "Power Transmitting Machinery" manufactured by this company. It is divided into several sections among which are: Gears and speed reducers, which covers 214 pages; pulleys; friction clutches; power transmission equipment, which includes hangers, hanger boxes, couplings, etc.; sprocket wheels and chain belting; miscellaneous appliances, such as rope sheaves, tension carriages, mule stands, belt tighteners, elevator heads and buckets, friction wheels, etc. This catalog contains 442 pages and is of a convenient size for reference.

The Yale and Towne Manufacturing Company, Stamford, Conn.—A folder describes the new Yale ball-bearing, spur-geared chain blocks which carry the load sheave on ball bearings. These blocks are made standard in capacities from ¼ to 20 tons, and special in 32 and 40 tons capacity.

Pittsburgh Transformer Company, Pittsburgh, Pa.—Bulletin 2038 describes the Pittsburgh self-cooled, radiator-type transformer which, it is claimed, is of quite sturdy construction, although light in weight for its capacity. Bulletin 2039 describes the Pittsburgh polyphase power transformers and shows their construction by illustrations.

Adjustable Clamp Company, 216 North Jefferson Street, Chicago, Ill.—Catalog 5 describes the Jorgens adjustable steel spindle hand screw clamp. The jaws are made of maple and the steel screw spindles operate steel nuts which are arranged to swivel within a convenient limit to permit adjustment of the jaws to conform to the surface clamped. These clamps are made in a variety of sizes up to 24 in.

Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.—Circular 1686 entitled "Micarta in the Central Station" describes applications of standard forms of Micarta and the method of applying on busbars, connections and in making cable joints, for barriers on circuit breakers and switches, its employment as bushings, slot wedges and cleats and other miscellaneous uses. The electrical and mechanical properties of the different grades of Micarta are also given.

Lyon Metallic Manufacturing Company, Aurora, Ill.—Bulletin 104-A shows the construction and methods of erection of this company's standard shelving, including label holders, box steps, shelving benches, shelf boxes and other equipment. Considerable space is devoted to a discussion of how to order shelving. Bulletin 108-A gives directions for erection of Lyon standard shelving, both adjustable and extensionable type.

Reeves Pulley Company, Columbus, Ind.—Folder T-3030 shows the use of steel link V-belt for use on variable speed transmissions. This is composed of hardened steel links flexibly bound with rocking pins. Leather tips on the V-belt come in contact with the sides of the cones to provide the tractive contact.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Publication C-2, entitled "Industrial Time-Limit Controller," describes this equipment, which is claimed to have special advantages for use in steel mill applications.

Hubbard and Company, Pittsburgh, Pa.—Catalog 24 gives a complete listing of Hubbard pole line hardware and Pierce construction specialties. This covers complete equipment for the construction of pole lines.

General Electric Company, Schenectady, N. Y.—Bulletin No. 4891-A entitled, "CR 9006 Enameled Resistor Units," lists and describes the various units which are suitable for use in connection with railway and fire alarm signals, locomotive headlights, telephone circuits, magnets, laboratory and measuring instruments, rheostats and panels.

Standard Conveyor Company, North St. Paul, Minn.—Catalog 1 entitled, "Wherever Conveying Is Done," illustrates a large number of installations of Standard roller gravity conveyor equipment.

General Electric Company, Schenectady, N. Y.—Bulletin 45609 describes the G. E. surface air cooler and the principle of the closed system of ventilation in re-circulating the ventilating air of a turbine generator back to the machine after it has been cooled by passing over the finned surface of a cooler using water as its cooling medium.

Greene Equipment Corporation, Monadnock Block, Chicago, Ill.—A circular describes the Acme armature washing fluid which is non-combustible, non-explosive and will not injure insulation.

Century Electric Company, St. Louis, Mo.—A booklet describes and gives prices on the Century Type SC, squirrel-cage, two- and three-phase induction motors, from ⅛ to 50 hp.

General Electric Company, Schenectady, N. Y.—Bulletin 67721, Class 17, describes the automatic switching equipment for synchronous converters in mining service, describes their operation and illustrates by diagram.

Roller-Smith Company, 229 Broadway, New York, N. Y.—Bulletin 100 covers a line of portable electrical instruments for signal-system testing. Bulletin 550 describes a series of direct-current relays operating with reverse current, overload, underload, overvoltage or under-voltage. Bulletin 430 describes the Roller-Smith line of direct-current switchboard instruments, such as ammeters, voltmeters, voltammeters, shunts and multipliers.

The Reinhart Electric Motor Company, 2517 Seventy-ninth Street, Cleveland, Ohio—Bulletin 180C describes the Reinco alternating-current, ball-bearing motors which are made in frac-

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tional sizes from ⅛ hp. up to 1 and also in 1½, 2, 3, 5, 7½, 10, 15, and 20 hp. capacity. Simplicity of construction and ease of assembling or dis-assembling as well as the alemite method of grease gun lubrication are among the features described.

Philadelphia Gear Works, Richmond and Tioga Streets, Philadelphia, Pa.—Catalog 13 entitled "Philadelphia Speed Reducing Unit" describes a line of worm, spur, spiral, bevel and herringbone gear speed reducers. Some of these are provided with ball or roller bearings. This catalog not only describes the construction of the unit, but also gives considerable engineering data regarding the dimensions and capacities of the various units.

Crouse-Hinds Company, Syracuse, N. Y.—Bulletin 2,058 describes the Wedgetite pipe hanger which consists of a hook and a saw-tooth edged wedge. The pipe or conduit is supported in the hook which is caught over the edge of an I-beam or channel and wedged in tightly.

Celite Product Company, 11 Broadway, N. Y.—Bulletin B-8-D describes the use of Sil-O-Cel as an insulating material for industrial furnaces and ovens. A number of sketches show how this material is to be applied.

Automatic Primer Company, 111 West Washington Street, Chicago, Ill.—This circular describes the Apeco primer for automatic starting centrifugal pumps through a cleverly arranged system of tanks and connections. This permits use of a centrifugal pump on suction lifts without mechanical contrivances for producing a vacuum and without foot valves.

Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A circular entitled "Commutator Slotter Bulletin" describes commutator slotters, undercutters and other tools for maintenance and repair work.

Buckeye Blower Company, Columbus, Ohio—Engineering Data Bulletin 133 contains complete description, capacities and other engineering information concerning all the various types of multi-blade fans produced by this company.

General Electric Company, Schenectady, N. Y.—Circular 66021 describes the single watthour meter indoor current transformer for circuits up to 4,500 volts on 25 to 60 cycles.

General Porcelain Company, Parkersburg, W. Va.—Bulletins 40 and 42 describe and price porcelain low-voltage and high-voltage insulators.

Lockwood, Greene and Company, 24 Federal Street, Boston, Mass.—A 40-page, handsomely illustrated booklet describes in detail some of the features which should be considered in planning an industrial power plant. The illustrations are of a number of industrial power plants installed by this company.

The John X. Tiffin Automatic Safety Valve Company, Detroit, Mich.—A folder describes the Tiffin automatic control safety valve which is designed for controlling numerous mechanical devices that at times of emergency require other and more efficient action than can be applied by the operators or the men in charge.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Folder 4531-A entitled, "Westinghouse Mica Insulation," describes the various grades of mica insulation and gives their different applications. Tables are included for reference, giving the size of sheet, the standard thickness and approximate weight per sheet of each form of insulation described in the booklet.

Allan Manufacturing and Welding Company, Buffalo, N. Y.—A folder describes the Almanc arc-welding transformers for use with alternating-current power and also arc-welding generators which are arranged to be driven by either belt, direct- or alternating-current motor or by gasoline engine.

Morse Chain Company, Ithaca, N. Y.—Publication 26-A entitled "Small Power Drives" gives, in addition to a number of applications of chain drives on motors from 1/16 to 100 hp. in industrial plants, an explanation of their operation, installation and maintenance, together with the principal advantages claimed for Morse chains in industrial works.

American Blower Company, Detroit, Mich.—Bulletin 1103 devotes 36 pages to American high-speed, double inlet fans, gives the characteristic curves, distinguishing advantages, construction features, capacity table and dimensions.

Wagner Electric Corporation, St. Louis, Mo.—Bulletin 133 entitled, "The Pow-R-full Starterless Motor," devotes several pages to the history of the induction motor, and particularly to starterless motors. Several pages are given to a technical discussion of the characteristics and other features of the starterless motor as well as to its construction with particular attention to its ventilation. Safety requirements and installation are also covered.

Groundulet Company, Newark, N. J.—A booklet entitled, "Groundits and Groundology," discusses metal conduit and pipe as conductors, the common ground conductor, and suggestions for grounding overhead a.c. service. The various types of "Groundits," special connectors for grounding, are also described in this booklet.

Harold E. Trent, 1524 Chestnut Street, Philadelphia, Pa.—Leaflets describe the Trent three-heat electric metal melting pot for continuous service, which is capable of producing temperatures up to 1,200 deg. F. Other leaflets describe the Trent automatic control system for continuous service which not only indicates the temperature but controls it, whether the heat is supplied by electricity or by gas, oil, steam, or heated air. This system is made in different sizes for various temperature requirements.

Esterline-Angus Company, Indianapolis, Ind.—Bulletin 724 entitled, "Clock Improvements," discusses changes which have been made in Esterline-Angus meter clocks with the view of making the performance better and giving better accessibility.

Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.—Bulletin 871 entitled, "Temperature Measurements in Generators, Transformers and Cable Systems," describes the operation and construction of equipment for indicating and recording the operating temperature of electric generators, transformers and power cables and other units which may heat.

The Truscon Laboratories, Detroit, Mich.—Folders describe the Truscon Super-Por-Seal, which is a transparent damp-proofing medium for treating cement and masonry without changing the color, texture or appearance of the surface. This is claimed to protect the surface against absorption and the penetration of water carrying grit, grime and dirt in suspension which would discolor or disfigure the surface.

The Ohio Electric and Controller Company, 5900 Maurice Avenue, Cleveland, Ohio.—Bulletin 204 describes the construction and operation of alternating-current, squirrel-cage, induction motors 110 to 440 volts, single, two or three phase, 25 to 60 cycle, and direct-current motors, 32 to 250 volts, of ⅛ to ⅓ hp. Another bulletin shows a large number of applications of these motors.

Champion Electric Company, 3711-3741 Forest Park Boulevard, St. Louis, Mo.—A booklet entitled, "Champion Endurance Motors," illustrates and describes briefly structural features of some of the more important parts of the different motors. These include single-phase, 60-cycle, repulsion-induction, ¼- to 5-hp. motors; squirrel-cage, 60-cycle, two- and three-phase, ¼- to 20-hp. motors; 110- or 220-volt, ¼- to 5-hp., d. c. motors; split-phase, 60-cycle motors of ⅛, ⅙ and ¼ hp. All but the split-phase motors are heavy-duty motors and are provided with either ball or bronze sleeve bearings.

Sundh Electric Company, Inc., 5 Avenue C, Newark, N. J.—Bulletin 18 entitled, "Sundh Electric Control for Fire Pumps," describes the manual, automatic and combined types of control. This booklet also gives the regulations of the National Board of Fire Underwriters and the amendments adopted by the National Fire Protection Association.

Gisholt Machine Company, Madison, Wis.—Bulletin DCT-5 describes the Gisholt direct-current transformer for securing direct current of low voltage from commercial lighting circuits, for operating bells, buzzers, annuciator and call systems, time stamps and clocks, elevator, sprinkler, fire alarm and other signal systems, or in other applications where low voltage, direct current is necessary.

McCord Radiator and Manufacturing Company, Lubricating Division, Detroit, Mich.—A 24-page booklet entitled "The Economy of Better Lubrication" gives the nine outstanding economies claimed to result from the use of McCord forced feed lubricators and illustrates a number of the applications recommended.

The Master Builders Company, Cleveland, Ohio—A 16-page booklet describes "Colormix," which is a concrete hardener, waterproofer and dustproofer in permanent colors and is used in many places where a colored floor or wall is preferred over the natural finish. In addition to a number of applications in various colors, specifications for its use are included.

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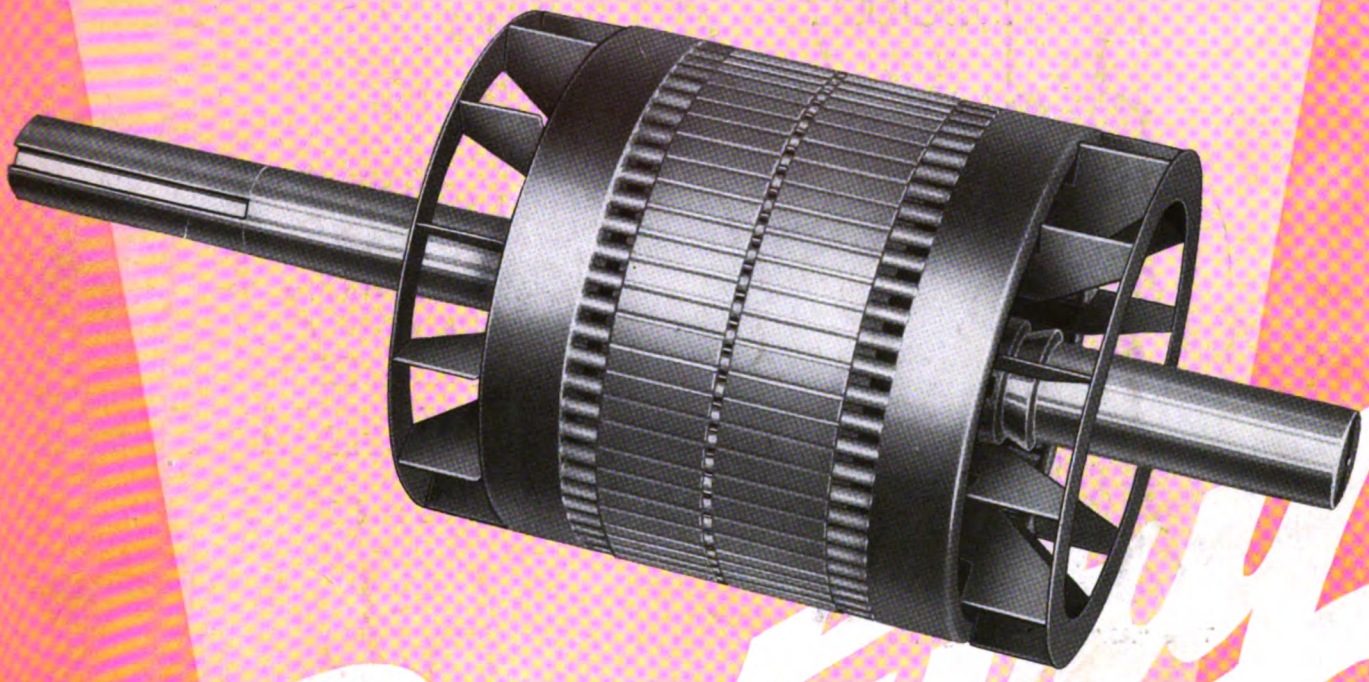
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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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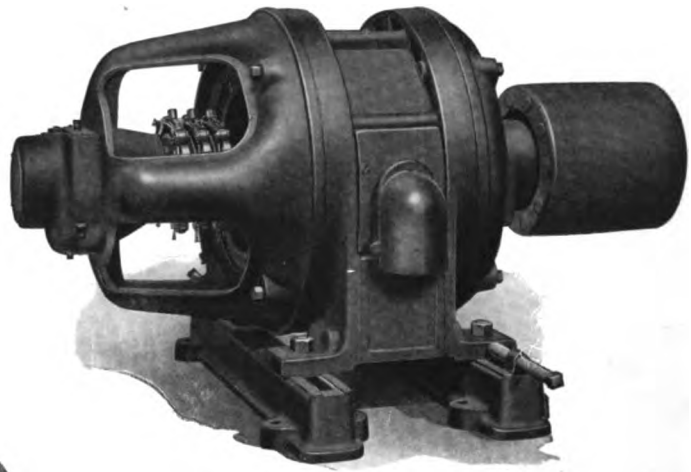
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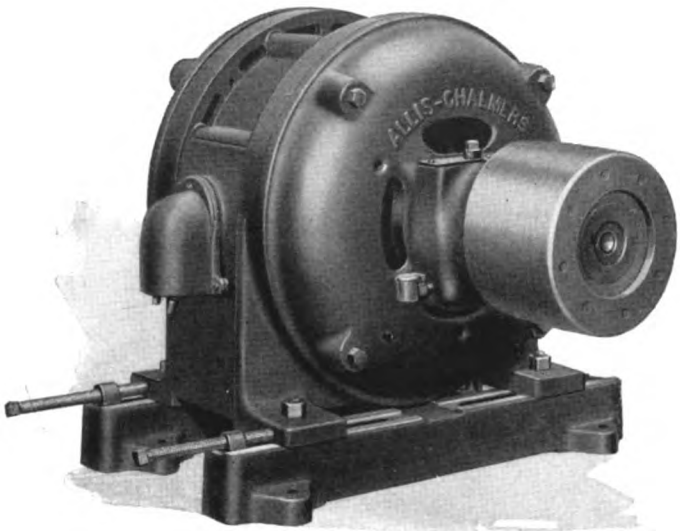
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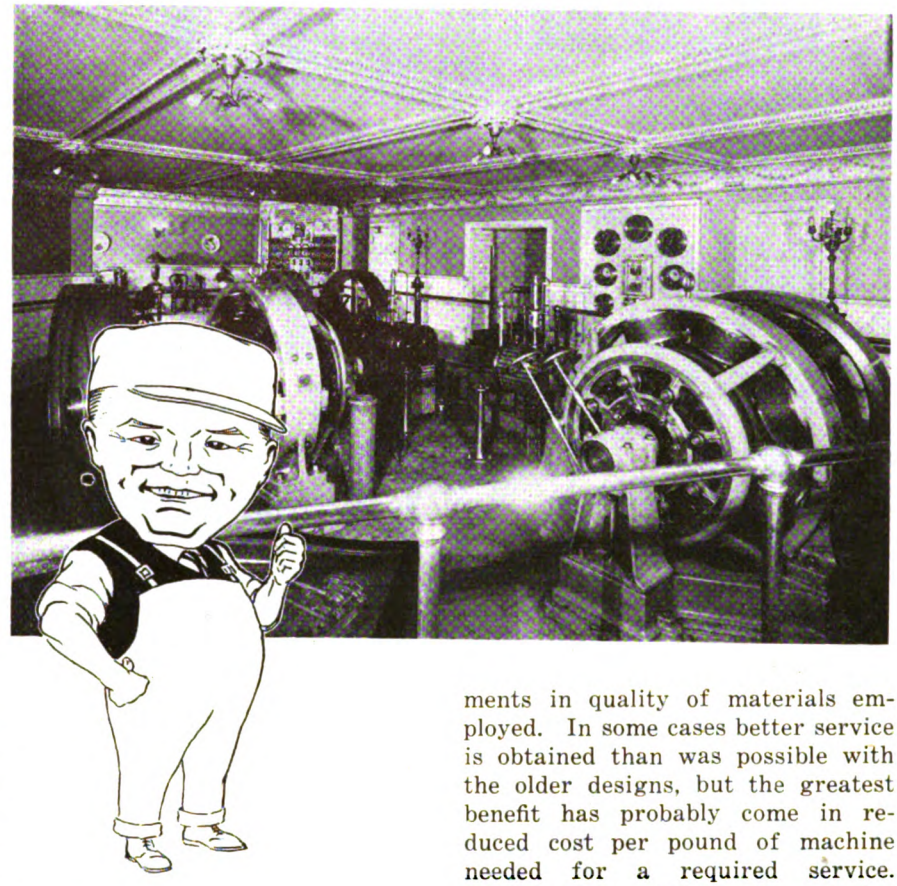
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 83 Chicago, April, 1925 *Number 4*

Still Running After 30 Years of Service

How These Generators Compare With Modern Standard Designs for the Same Kind of Duty



SOMETIME during 1895 the three generators shown in this photograph were installed in the Keith Theatre at Boston, Mass., and have been in service ever since. These old timers stand as silent witnesses to the sturdiness of designs of machines built 30 years ago.

The nameplates bear General Electric Company's serial numbers 1986, 1987 and 1988 with the rating indicated as MP-8-100-270, 108 volts no load and 112 volts full load. Harrisburg 150-hp., 15-in. by 14-in., single-cylinder engines, made by the W. R. Fleming Engine Company, were direct connected to them.

If these generators were to be replaced today the new ones would look quite different, by reason of the progress that has been made in design and construction to better suit operating conditions. In this particular instance the engineering department of the General Electric Company has furnished me the following statement comparing the features of modern generators for the service that these old ones have so well performed, based upon the revisions in design that have been worked out.

"Compared with the old Keith Theatre generators, the modern 100-kw., 125-volt, direct-connected generator is very much smaller and has commutating poles, with its main poles built up of laminations. The main poles are consequently, rectangular in cross-section, whereas the generators in the Keith Theatre have cast poles with cylindrical magnet cores. The following data enables a comparison to be made of certain elements as between what may be considered the original 100-kw., direct-connected generator for lighting service, and the latest General Electric standard generator."

	Keith Theatre Generator	Modern Standard Generator
Speed, r.p.m.	270	260
Number of poles	8	6
Diameter armature core overall, in.	45⅛	30
Length armature core overall, in.	12½	11
Number armature slots	136	79
Number commutator segments	272	79
Volts per segment	3.3	9.5

This information seems to indicate that today the materials in modern generating apparatus are worked harder and closer to design limits through improved construction, and through better insulation and refinements in quality of materials employed. In some cases better service is obtained than was possible with the older designs, but the greatest benefit has probably come in reduced cost per pound of machine needed for a required service. Whether this reduction in cost plus the cost of maintenance over a period 30 years from today will be less, cannot be answered conclusively until 1955, but it is a safe prediction, I think, that in 1955 we will know enough more about service requirements and both buy and use electrical apparatus with enough more intelligence and knowledge of what should be demanded in the way of efficiency to justify perhaps even closer limits of construction in 1955 than a comparison between designs of 1895 and 1925 now reveal. If anybody else has ideas along this line I have a way to make use of them and will welcome their comments.

Practical Pete

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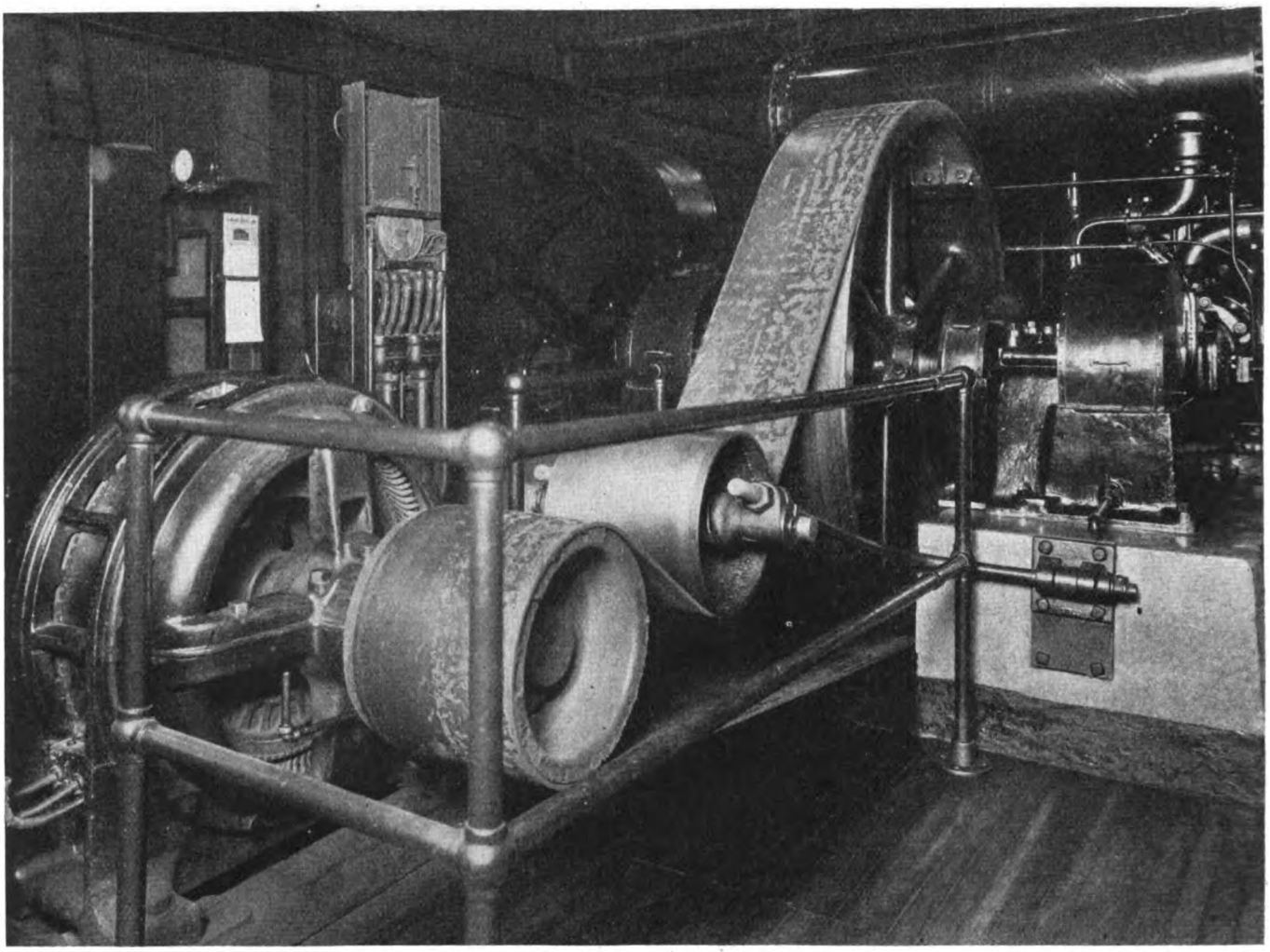


Fig. 1—Details of the arrangement of a short-center drive for an air compressor.

The idler pulley is held in position by two rods, one on each side of the idler, which are anchored to the foundation of the compressor. Half of the weight of these rods is used in computing the total idler weight. The location of the grease cup on the idler shaft can also be seen. Further details of the methods of lubricating the idler are given in Fig. 7 and on page 209. An 85-horsepower, 560-r.p.m., squirrel-cage, induction motor drives the air compressor through a 14-in. standard double-ply belt. The diameter of the motor pulley, driven pulley and idler are 18 in., 72 in. and 16 in., respectively, all pulleys having a 15¼-in. face.

What You Ought to Know About

Laying Out Short-Center Belt Drives Using Idlers

To Give Increased Arc of Contact Between Belt and Pulley, Together With Data, Tables, and Worked-Out Examples Showing How Typical Layouts Were Planned

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

SHORT belt drives with idler pulleys are used to economize floor space in numerous applications. In many cases they are more satisfactory than gearing, and frequently offer important advantages over a direct-connected motor drive. As an example, a medium-speed, synchronous motor driving a compressor through a short belt costs less than a slow-speed, direct-connected drive, and allows the purchaser to choose a compressor large enough to take care of several years' expected growth and still gain the advantage of somewhat increased economy and greatly decreased maintenance expense in the interim by simply installing at first, an undersized motor pulley. This case is illustrated in Fig. 5. There also exists the possibility of getting the compressor back into service in case of motor trouble, by temporary use of almost any available large motor and a suitable size of pulley. If the motor available is not large enough to drive the compressor at full speed, then pulley sizes may be selected that will drive the compressor at such a speed as will fit the capacity of the motor.

Around a factory many other applications suggest themselves, such as heating fans, as shown in Fig. 3, cupola blowers of the centrifugal or

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positive pressure type, plunger pumps, exhausters, and various drives where space is at a premium and the speed of the driven machine is too slow to permit direct connection, or on drives where there is a worth-while advantage in an arrangement which makes possible some changes in speed by a change in pulley sizes, as is shown in Fig. 5.

In the case of a compressor, the short-belt drive attachments, idler pulley, supporting rods, etc., are ordinarily furnished by the compressor manufacturer. For short-center drives that are built or constructed in the plant, it will be necessary for the operating man to determine the size and weight of the idler pulley and the other factors determining the character of the drive. It has been my experience that the average draftsman with considerable experience along such lines is somewhat puzzled when asked to determine the correct weight of idler for such a drive. He generally estimates the weight from that of another drive, with a liberal allowance for safety. If the man laying out the previous drive did the same thing, and in turn his predecessor, we arrive at very large factors of safety against slipping and very high resulting belt stresses.

I am outlining, in what follows, a rational method of laying out such drives. With the help of some data, which I have taken from both unsuccessful and successful drives, it is comparatively easy to plan a drive for a specific purpose, without using an unreasonably heavy idler pulley to insure against slip.

There are several factors to be considered in planning a short-center belt drive. These factors will be considered in what follows: horsepower to be transmitted, speed of drive pulley, belt speed, belt thickness, effective tension, belt width, static tension, and weight of idler.

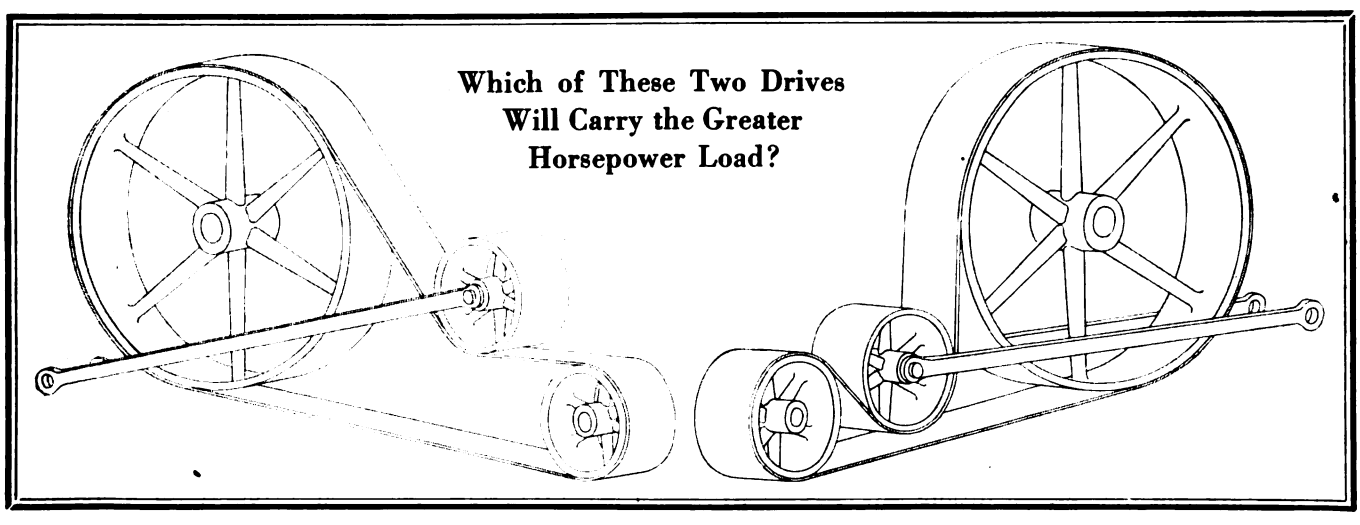
SHORT BELT DRIVES with idler pulleys to increase the arc of contact between belt and pulley are used to save floor space, building space, and belting, as well as bearing friction, lubrication, and bearing renewals because of the reduced bearing pressure obtained thereby. The short-center drive having an idler permits the use of less expensive, high-speed, high-efficiency motors because pulley ratios that are higher than those customary with any other form of belt drive may be used with it. Determining the correct weight of idler, selecting the proper belt tension, and making proper allowance for possible overloads and other factors determining the layout for such a drive is often a puzzling matter. In this article, Mr. Drake outlines a rational method for planning such drives and with the help of several tables based on his experience, he works out a number of typical examples of short-center drives.

Calculation of Horsepower to be Transmitted by Belt

Strictly speaking, the idler weight must be proportioned to give sufficient belt friction on the driving pulley for the maximum instantaneous horsepower and not for the average horsepower to be transmitted by the belt. Thus for a belt driving a single-stage air compressor having a large variation of torque in a revolution, a heavier belt and a heavier idler will be necessary than for a fan. For a two-stage compressor, intermediate values will be indicated. Thus, in a strictly academic discussion of the problem, it would be logical to determine the maximum horsepower transmitted at any point in the revolution of the driven machine and base the layout on this value. Such a method would allow the use of the same empirical constants for all types of drives, from a severe shock load to a fan. Unfortunately, data as to the crank effort diagram of the driven machine, the effect of flywheel weight, and the motor slip, or relative drop in speed with various instantaneous loads, is seldom easily available. I have, accordingly, developed a design procedure based upon the average horsepower during a revolution with maximum load being transmitted by the drive, with a range in the empirical design constants to be applied by judgment according to the type of load, as to variability of torque during a revolution. This greatly simplifies the computations and has given satisfactory results in practice, where the variations of required driving torque are not extreme, and where the torque during the starting period does not greatly exceed the average full-load torque, as when the motor is started with one or more steps of reduced voltage by an ordinary resistance-type starter in the case of a direct-current motor, or a compensator starter in the case of an induction motor. Therefore, in the computation that follows we will use the value of horsepower required by the driven

Fig. 2—The answer to the question stated below is determined by the position of the idler pulley.

Both drives have the same size and thickness of belting and the same diameters and faces of driving and driven pulleys; in fact, both drives are the same except that in the case of the right-hand illustration the idler pulley is hung lower, thus giving a larger contact area of the belt with both pulleys. At first thought it would appear that the drive shown at the right would carry the larger load, because of the greater belt-contact area. On page 171 and in Fig. 4, the author shows that the facts are precisely the opposite.



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Table I—Permissible Effective Pull and Slack Side Tension for Different Belt Speeds

Belt Speed in Ft. per Min.	Permissible Effective Pull Per Inch of Belt Width for Standard Double Belt			Belt Speed in Ft. per Min.	Necessary Slack-Side Tension in Per Cent of Effective Pull		
	A	B	C		A_1	B_1	C_1
0	38.0	79.0	104.0	0	35	35	35
500	46.0	94.0	124.5	500	18	18	18
1000	47.0	97.0	128.0	1000	16	14	12
2000	45.0	96.0	129.0	2000	16	12	10
3000	40.0	91.0	123.0	3000	32	20	18
4000	32.5	84.5	116.5	4000	60	30	25
5000	23.0	75.0	107.0	5000	135	45	35

For single ply (¼-in. thick) use 50% of above values. For light double ply (⅜-in. thick) use 75% of above values. For medium double ply (⅞-in. thick) use 94% of above values. For standard double ply (½-in. thick) use 100% of above values. For three-ply (¾-in. thick) use 150% of above values.

These percentages apply to belts of any thickness. The percentages in column A_1 apply to the data in column A; those in column B_1 to column B; and those in column C_1 to Column C.

(1) This table is correct for short belt drives with idlers, where the motor pulley is made of paper and the drive is so laid out that the arc of contact with the motor pulley is from 210 to 230 deg. when the belt has stretched so that the upper belt almost touches the lower belt. This table is not intended for use with lineshaft drives without idlers, nor with the idlers unless the smaller pulley is paper.

(2) Column *A* is based on a total tension on the pull-side of 54 lb. per in. width of double-ply belt running at a speed of 4,000 ft. per min., with slightly different values at other speeds as recommended by Barth. With excellent maintenance based on F. W. Taylor's experiments at Midvale, this should give a belt life in 24-hr. service of 18 yr. Few belts get such excellent care. Use data from this column for drives in 24-hr. service, or important drives in 10- or 12-hr. service where a delay from belt trouble once in a year or two would be serious or troublesome and where the additional first cost is warranted to avoid it.

(3) Column *B* is based on a total tension on the pull-side of 111 lb. per in. width of standard double-ply belt running at a speed of 4,000 ft. per min., with slightly higher tensions at lower speeds and slightly lower tensions at higher speeds, approximately according to Barth's recommendations. According to Taylor's experiments, belts run 24 hr. per day with about this total tension will last seven years if given exceptional maintenance. The data in this column are suitable for the design of drives carrying a very constant load (no fluctuations) where the equipment is operated only a few hours per day or only a few months per year, for example, heating fans. These data are also suitable for the layout of drives carrying a constant, or nearly constant load, such as ventilating fans, where operation is for 10 or 12 hr. or more per day, and where a case of belt trouble occasionally will not interfere with production.

(4) For drives where the torque is fairly uniform, as on compressors with flywheels, Root or Connelsville blowers, and the like, use effective pulls between the values in columns *A* and *B*, using values nearer those in column *A* for 24-hr. service, for more important drives, and for drives where the torque is more variable (as on single-stage compressors); and values nearer column *B* for 10-hr. service on less important drives and for drives where the torque is less variable, such as on two-stage compressors.

(5) Column *B* is also suitable for checking or planning a drive for starting conditions or high swings with extremely variable load where this is likely to be the limiting feature of the design, and the most extreme reliability is essential, or where the service is exceptionally severe as in the frequent starting of a squirrel-cage induction motor in a location where there is dust which will decrease the friction of the belt on the pulley, and where the belt will not be well cared for.

(6) Column *C* is based on a total tension on the pull side of 146 lb. per in. of width of standard double-ply belt at 4,000 ft. per min. with slight variation for higher and lower speeds. This was about the stress which was considered advisable by old-time millwrights. Engineers of late years have been using lower stresses because of the greatly increased belt life, greater reliability, and lower maintenance. I do not recommend the use of such stresses for steady running in any design, even for occasional use. However, it is reasonable to use such stresses during the starting period on drives where more torque is exerted during starting than during running (such as cases where small induction motors are started "across the line" without a compensator) and where such stresses do not occur too frequently.

(7) On drives where the maximum torque of the motor is two or two and one-half times the nameplate rating, and the nature of the load is such that this torque or something approaching it may be expected to be exerted occasionally (for example, a jaw crusher for rock) it is necessary to check the design for maximum torque. If the drive is unimportant and occasional belt trouble not of serious importance, the values in column *C* are reasonable for this purpose. If reliability is of more importance or conditions are unfavorable to the belt, such as dust, out-of-the-way location where poor maintenance may be expected, and the like, it is often advisable to use values somewhere between those of columns *B* and *C* for checking maximum torque. Only where the maximum torque of the motor is exerted frequently and extreme ruggedness and reliability are desired is it necessary to keep the stresses as low as those of column *B* at the stalling point of the motor.

(8) Use the percentages in columns A_1 B_1 and C_1 in determining the slack-side belt tension for loads having a variation in torque no greater than that of a two-stage compressor or a Root blower.

(9) For loads having a variation of torque in each revolution, like a single-stage compressor with a flywheel, multiply the above percentages by 1.15.

(10) For loads having greater variation in torque than a single-stage compressor with flywheel, such as any mechanism having a crank and *no* flywheel, compute or estimate the maximum torque during the revolution and figure both effective pull and per cent static tension on that basis. In such a case use the above percentages unaltered.

(11) The percentages in columns A_1, B_1 and C_1 apply to drives where the angle of contact between the belt and driving pulley is 210 to 230 deg. when the idler pulley is at its lowest position. Most such designs as we are considering fall within this range. In case special conditions make it advisable to lay out a drive where the angle of contact falls outside this range, correct the above table by multiplying the tabular percentages by constants as follows:

Angle of "Wrap"	Multiplying Constant
180 deg.	1.12
190 deg.	1.09
200 deg.	1.06
240 deg.	0.965
250 deg.	0.95

machine for the maximum continuous load that will ever be carried for any length of time. If the driven machine will be overloaded for several minutes, this load must be used.

There are certain drives which have not lent themselves readily to this method of treatment, such as drives where a torque occasionally occurs either during starting or running, which is very large compared to the average torque. In general, these occasional extreme torques are the limiting conditions in such drives, and the drives must be planned to meet them, both as to the size and strength of the belt required and as to the weight of idler necessary to prevent the belt from slipping. Such drives are:

(*a*) Machines driven by small squirrel-cage, induction motors which are started directly across the line. Such motors ordinarily develop at starting 125 to 150 per cent of full-load torque, which gradually increases with increase of speed until at roughly 75 per cent of full speed they develop 200 to 250 per cent of full-load torque (not horsepower). The lower value is for slow-speed motors, say up to eight poles and the larger value is for four- and six-pole motors.

(*b*) Some machines in severe applications, such as coal or rock crushers, not infrequently sustain momentary loads approaching the maximum or stalling torque of the motor. Often the shearing pins break at this load. In the case of some kinds of machines, a horseshoe

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or some freight-car part comes through in the raw material just often enough so that it is impracticable to burn up a belt every time this happens.

My method of designing such drives is to so proportion the belt and idler pulley, that the drive will carry the maximum torque or stalling torque of the motor without injury to the belt through over-stress or slipping of the pulley.

If these extreme stresses are infrequent, it is unnecessary to maintain as low belt stresses through their duration as would be reasonable for continuous operation. Suggestions for suitable stresses to allow during these extreme overloads will be found in the notes following Table I.

Generally, it is necessary to figure such a design through for average running conditions and again for starting or extreme overload conditions. The weight of the idler pulley required is almost invariably determined by the starting or overload conditions. The size of belt required is sometimes determined by the overload or starting condition and sometimes by the normal load condition. This seeming anomaly is due to two facts.

(*a*) The design for the occasional heavy load during starting or overload is figured on a basis of heavier belt stresses than is the normal running load.

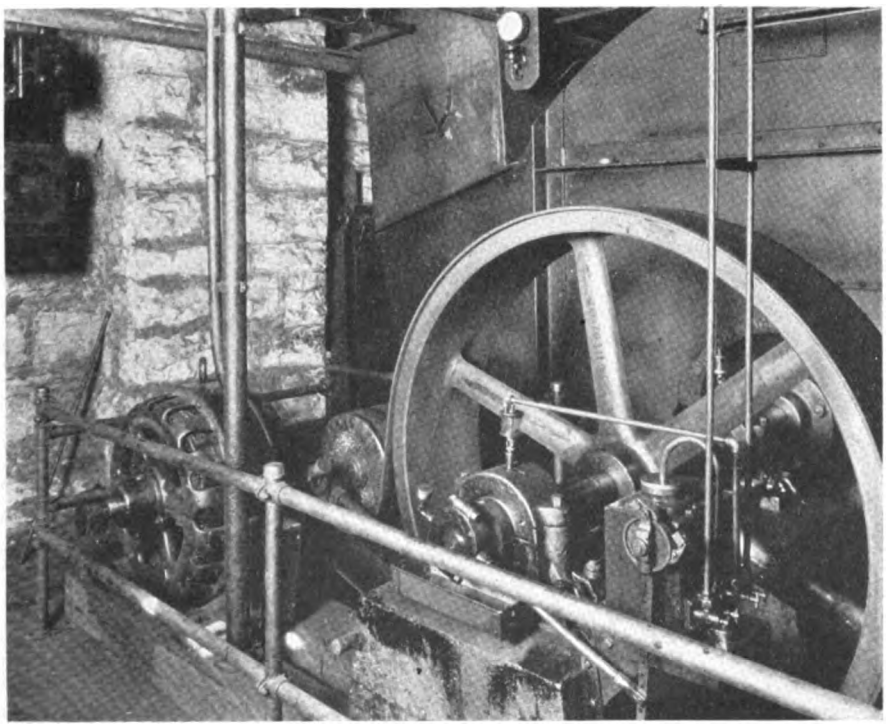
(*b*) The extreme load or stalling torque occurs at approximately 75 per cent of normal speed. If the drive is so planned that the belt speed is close to 5,000 ft. per min. at normal running speed, the belt will be working under much more favorable conditions as to grip on the pulley at 75 per cent of that speed (see Table No. I).

When the weight of idler pulley necessary to carry the occasional heavy torque in a drive of this kind greatly exceeds the weight of pulley necessary for normal running and the design for normal running happens to determine the size of belt, it is well to increase the belt width slightly to allow for the increased weight of idler pulley over that corresponding to the assumptions on which Table I was calculated. Particularly is this true when normal running stresses are assumed higher than those shown in column *A*, Table I.

A direct-current, compound motor or even a shunt motor is capable of exerting a torque far greater than 200 to 250 per cent of full-load torque. Such motors are seldom started across the line, except in extremely small sizes, but they are sometimes used on drives where they develop extremely high, momentary torques. In designing a short-belt drive for such an application, I know of no rational procedure except to determine by some means the maximum torque to be expected.

Fig. 3—This motor and short-center belt drive have replaced the steam engine formerly used.

The flywheel on the steam engine was used for the driven pulley and the short-center drive shown just fits into the space formerly occupied by the engine. A 75-hp., two-speed, 600-1200-r.p.m., squirrel-cage, induction motor is used, which drives the heating and ventilating fan through a 12-in. belt. A 12-in. diameter pulley is used while the diameter of the driven pulley is 60 in. and the diameter of the idler is 16 in. The pulley faces are 13 in. wide.



Effect of Drive Pulley Speed and Belt Velocity

The drive pulley speed is generally fixed by the speed of the motor to be used. If an attempt is made to design a drive for a motor having too high a speed, it will figure out unreasonable in proportions and the necessity for a change in motor speed will be evident.

Within certain limits, as the speed of the belt is increased, the width of the belt may be decreased. This causes less load on the motor bearings, which gives longer life and cooler running. Increasing the belt speed and at the same time keeping the shaft or pulley r.p.m. the same, means increasing the pulley diameter which results in the belt being bent less sharply over the pulleys, thereby giving a longer belt life. Carried to an extreme, this results in belt speeds such that the belt tends to leave the pulley by centrifugal force and the actual power transmitted by friction is greatly reduced. Translating this into definite figures means that up to a maximum of 4,000 to 4,500 ft. per min. belt speed, the higher the belt speed, the better and cheaper will be the design; from 4,500 to 5,000 ft. per min. there is no worth-while gain unless starting conditions are rather severe; beyond 5,000 ft. per min., the drive is definitely poorer and more expensive.

Then let us say, make the speed as near to 4,000 to 4,500 ft. per min. as other conditions will allow. Generally this speed is limited by the largest pulley which can be put on the driven machine without striking the floor or the ceiling, by the size of flywheel furnished as standard by the manufacturer (as on a compressor), where a change would be too expensive to consider; or by some other similar consideration.

Considerations Affecting the Belt Thickness

In some cases the question may arise in the designer's mind whether to use single- or double-ply belt, or whether to use double- or triple-ply belt. In this connection, F. W. Tay-

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Table II—Analysis of Six Examples of Short-Center Belt Drives

Hp. Load by Test	Motor R.P.M.	Belt: Width	Belt: Thickness	Belt: Effective Pull per Inch of Width	Belt: Velocity of Belt Ft. per Min.	Belt: Type of Belt Splice	Pulley Diameter	Weight of Idler, Shaft, and ½ of Rods	Weight of Idler, etc., per Inch Belt Width	Idler at Lowest Position: Static Idler Tension per In. of Belt Width	Idler at Lowest Position: Arc of Belt Contact in Degrees	Idler at Lowest Position: Static Tension in Per Cent of Effective Pull	Idler Lifted ½ Pulley Diameter: Static Idler Tension per In. of Belt Width	Idler Lifted ½ Pulley Diameter: Arc of Belt Contact in Degrees	Idler Lifted ½ Pulley Diameter: Static Tension in Per Cent of Effective Pull	Nature of Load	Remarks
70	580	15	Dble.	62.5	2580	Cemented	17.0	287	19.0	10.0	236	16.0	15.5	206	25.0	Two-stage compressor	Entirely successful
70	580	15	Dble.	62.5	2580	Cemented	17.0	192	12.8	6.67	236	10.7	10.4	206	16.7	Two-stage compressor	Slipped every time splice passed pulley
44	1150	12	Dble.	40.0	3610	Cemented	12.0	183	15.2	8.3	230	21.0	12.0	210	30.0	Fan	No slip whatever. Belt doesn't touch drive pulley at edges. Contact width 7 to 8 in. instead of 12 in.
160	600	28	Dble.	66.7	2830	Cemented	18.0	880	31.5	18.2	208	27.0	20.5	204	31.0	Two-stage compressor	Successful. Slip not apparent but smell leather frequently. Measured slip, 1.4%, which is normal.
11	1150	4	Single	24.0	3600	Cemented	12.0	41	10.3	....	225	....	....	....	....	Vent. Fan	Entirely successful if motor is started with compensator.
(	580	18	Dble.	47.0	2330	Cemented	15.5	....	....	....	229	....	....	....	....	Root Blower	Motor starts against heavy inertia load. No apparent slip at start or running.

lor, as a result of his classical experiments at Midvale, continuing through nine years, recommended as follows:

(*a*) Belts are more durable and more satisfactory when made narrow and thick rather than wide and thin.

(*b*) It is safe and advisable to use a double-ply belt on a pulley 12 in. in diameter or larger; a triple-ply belt on a pulley 20 in. in diameter or larger; and a quadruple-ply belt on a pulley 30 in. in diameter or larger.

These recommendations were based mostly on drives without idler pulleys. Where idler pulleys were used, they were not close to the driving pulley, as in the class of drives which we are considering, but several feet distant. Therefore, the sharp reverse bend around the idler pulley, which is characteristic of our drives, was absent. It is likely, therefore, that it will be best when possible, to modify Taylor's recommendations to the following:

Do not use double-ply belts on pulleys smaller than 14 in. in diameter.

Do not use three-ply belts on pulleys smaller than 24 in. in diameter.

Do not use four-ply belts on pulleys smaller than 36 in. in diameter.

Where the special exigencies of the design demand it, it is perfectly practicable to use the smaller pulleys in Taylor's recommended list and "get away with it."

Selection of Effective Belt Tension

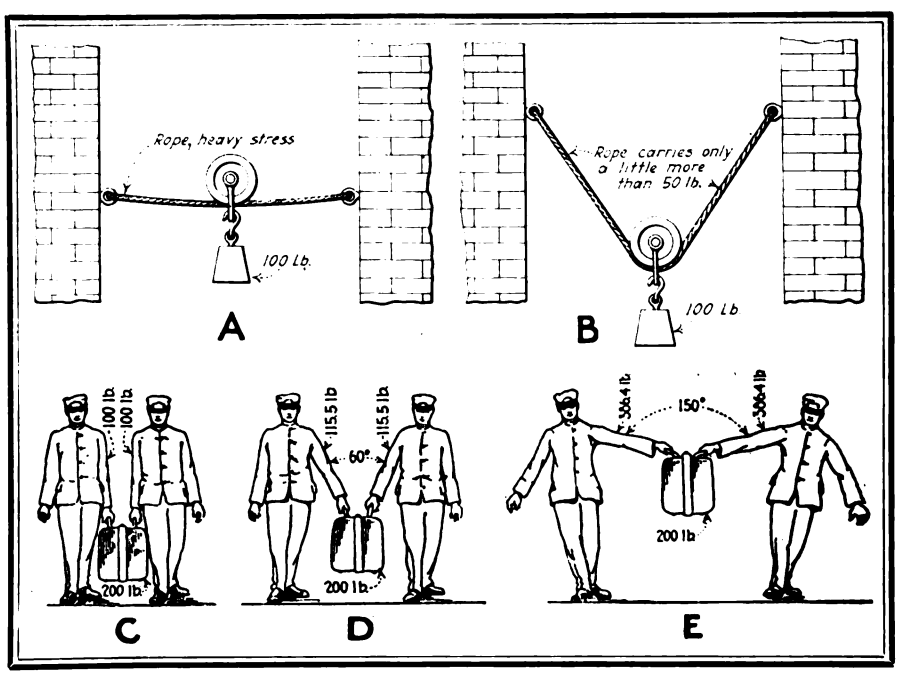
In the middle of page 167 we spoke of the variation of the torque in a revolution, required by some drives. This torque variation causes a variation in the tension on the belt. In our calculations for the drive we will use an average value of belt tension which we will call the effective belt tension. These values, which are given in Table I, have been determined from my experience.

Most pulleys are made nowadays of paper. The constants and discussion here given assume that paper motor pulleys will be used. With iron or wood pulleys larger belts are necessary.

For short-center belt drives you can work the belt somewhat harder than on an ordinary drive for the ratio of the slack-side tension to the pull-side tension is far lower than with direct drive. The total tension on the pull-side is correspondingly reduced. This is partly due to the large arc of contact on the small pulley, partly to the fact that the slack-side tension is fixed by the designer and no overstressing is necessary to allow for subsequent slacking off as the belt stretches, and partly to the fact that the small driving pulley is paper. Our experimental results check this conclusively. The best known data on belt stresses

Fig. 4—Is the rope shown at A under greater stress than the one shown at B?

The answer is yes and is borne out by the two men carrying a heavy traveling bag, as shown at *C*, *D* and *E*. At *C* the men stand close together with their arms hanging straight down and parallel so that each carries half the weight of the bag, or 100 lb. At *D*, they are standing farther apart, which means they must pull a little as well as lift, with the result that there is a tension on their arms of 115.5 lb. At *E*, it can easily be seen that they must exert quite an effort in lifting the bag. Diagrams *A* and *B* are analogous to the left-hand and right-hand diagrams, respectively, of Fig. 2.



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are probably F. W. Taylor's* published values based on his experiments at Midvale. Many engineers know how their practice in ordinary belt drives compares with his recommendations. For this reason in the notes following the tables, I give some reference to the two types of belt drive designs discussed by him, that is, to layouts in which the maximum stress in the belt is limited to 54 lb. per in. width of double belt as he recommended, and layouts in which stresses of about double that value are permitted.

Methods of Finding Belt Width and Static Tension

Having selected from the data in Table I an appropriate value for the effective tension per inch of belt width, compute the belt width according to the following formula:

Width in inches equals (horsepower×33,000)÷(belt speed×effective tension per in. of belt width).

With the motor and driven machine stationary, there is a tension on the belt due to the weight of the idler pulley. If there were no friction in the bearings, this tension would be equal in all parts of the belt when the machine is not running. For want of a better name, we will call this the static tension. A certain minimum static tension is necessary to produce the necessary friction between the belt and the driving pulley. Once we determine this necessary static tension, we are in position to determine the weight of the idler pulley required to produce it.

*Transactions of the American Society of Mechanical Engineers, Volume 15.

Table III—Relation of Contact Arc to Loading

With a given net tension (static tension less tension due to centrifugal force) in the belt on the slack side of the pulley, a drive will carry the following relative loads with variation in proportion of pulley surface in contact with belt.

Arc of Contact in Deg.	Relative Loads	Arc of Contact in Deg.	Relative Loads
150	0.85	200	1.06
160	0.90	210	1.09
170	0.95	220	1.12
180	1.00	230	1.14
190	1.03	240	1.16

The study of the design data and operating results of six drives in service (see Table II) indicates that a convenient method of estimating this static tension, is by the use of a percentage of the average effective tension.

The conditions as to arc of contact, angle of supporting rods and necessary static tension are not constant for any one drive. As the belt stretches the idler takes a lower position, the arc of contact increases, and due to the change in the angles of the belt on the slack side, the static tension decreases. When the upper belt almost touches the lower, the operator moves the motor away from the driven machine, which raises the idler, and the process starts over again.

It would appear at first thought that a drive would carry more load when the idler is low, as shown at the right of Fig. 2, than when the idler is high, as shown at the left of Fig. 2. The contact area of the belt on the pulley is greater in the former position. Almost any millwright or operating man takes this view of the matter. If he has trouble, he adjusts the motor on its base to obtain greater wrap of the belt on the driver pulley. The facts are precisely the opposite.

The maximum load which the drive will carry without excessive belt slip depends somewhat upon the arc of contact, but not in proportion to that arc. The exact relationship is shown in Table III. This shows that for arcs above 180 deg. the gain is not great. The maximum load depends also upon the static tension or stress on the slack side of the belt, and (belt velocity remaining unchanged) is directly proportional thereto. It is this loose-side tension which keeps the belt in contact with the driving pulley, and produces the driving friction. Now, once the weight of the idler pulley is fixed, this loose-side tension depends upon the position of the idler. The conditions are exactly analogous to those shown in Fig. 4. It is evident that the stress in the rope will be enormously greater at *A* than at *B*. This effect is so much more marked that it entirely offsets the disadvantage of less arc of belt contact on the driving pulley in the case at the left of Fig. 2 and further greatly increases the maximum horsepower load possible for the drive to carry. However, the fact remains that the millwright or the operating engineer almost invariably

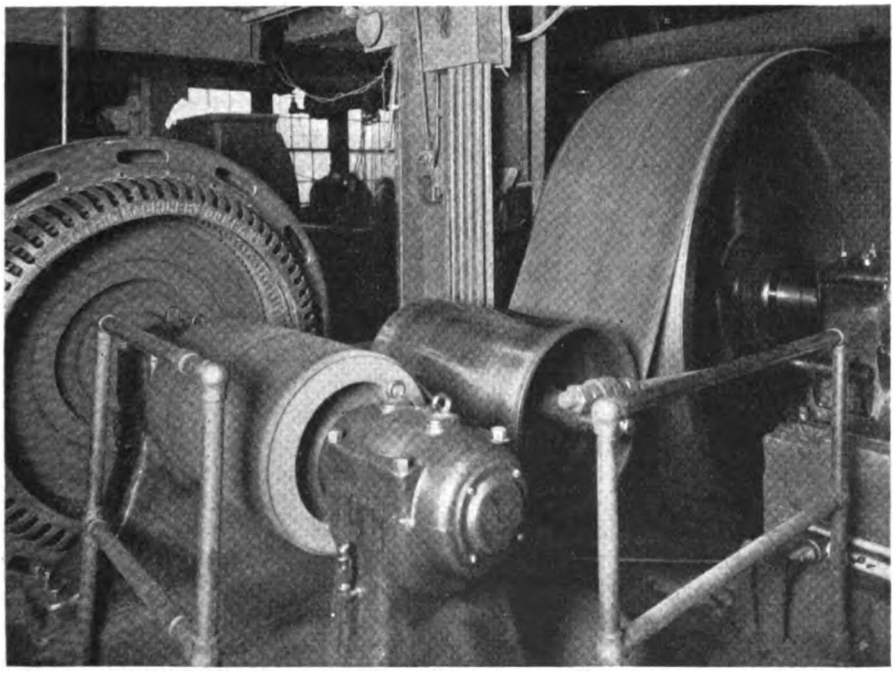


Fig. 5—The small space available made a short-center drive imperative at this location.

This drive is located in a basement, one wall of which is just to the left of the motor (cannot be seen in illustration) and the other wall is immediately to the rear of the air compressor. This air compressor is driven by a 450-hp., 600-r.p.m., synchronous motor through a 28-in. standard double-ply belt running over a 16-in. motor pulley and an 84-in. air compressor pulley. The idler is 22 in. in diameter. All of these pulleys have a 29-in. face. As can be seen this drive is coupled very closely together. With the arrangement as now used, the air compressor runs close to 120 r.p.m. with the 450-hp. motor developing about half of its normal rating. When the requirements for air become heavier a larger pulley will be placed on the motor, thus speeding up the air compressor so as to meet the new requirements. Since the efficiency of the synchronous motor is only about 2 per cent lower at half-load than at full-load, this arrangement of motor drive makes a very desirable combination, giving high economy and low maintenance for present requirements and yet having sufficient capacity to take care of anticipated future growth.

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fails to see it that way, and even if instructed by a card or booklet shipped with a purchased machine, or by word of mouth, his successor will not be benefited. Every drive should be designed so that it will operate entirely satisfactorily in such a position as that shown at the right in Fig. 2. If through error, or failure to appraise correctly the degree of non-uniformity of torque, the designer fails to proportion the weight of the idler pulley correctly, it is often possible to operate the drive satisfactorily by shortening the belt. In such a case it is best to arrange a stop to make it impossible for the idler to take a low position, or to supply a heavier idler pulley when convenient. Otherwise, trouble and dissatisfaction are sure to follow.

Before the above digression we had progressed to the point of determining the static tension. We had decided that as convenient a basis as any for tabulating the results of experience for use in future designs was to express this quantity as a percentage of the average effective tension. Then during our digression we decided that it was advisable to proportion all designs on the assumption that they would sometimes be called upon to operate in the position shown at the right in Fig. 2. Based on the above premises and an analysis of the six drives ranging from 5 hp. to 200 hp. given in Table II, reasonable assumptions for the static tension expressed as a percentage of the average effective tension are given in columns A_1, B_1 and C_1 of Table I. The data for a belt speed of 5,000 ft. per minute, which lies somewhat beyond any of our experimental values, were determined by computing the effect of centrifugal force, by the method of analysis published by Carl Barth** with modifications of the constants for the difference in assumed conditions. Since no experimental data at this speed on a drive of the type which we are discussing were available, a larger factor of safety was introduced into these data; that is, the data at 5,000 ft. are presumably safer than the remaining data in Table I.

How the Required Idler Weight for an Installation Is Found

So far, we have determined our effective tension and from it, by the selection of an appropriate percentage from Table I, our static tension. The last step is to determine the necessary weight of idler, including therein that part of the weight of the supporting rods and fittings, which is borne by the idler. Let us call this total the effective weight on the idler. The best method for obtaining this weight is by a simple layout.

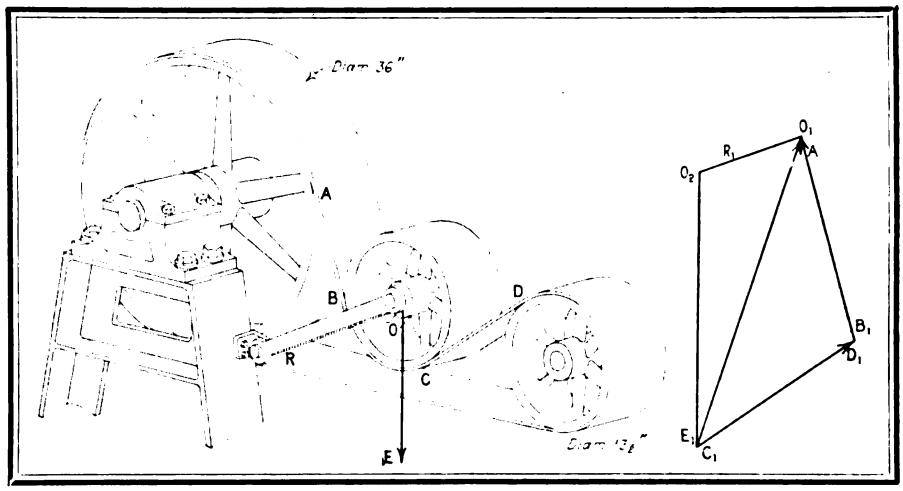


Fig. 6—Method of determining the weight of idler required for a short-center belt drive.

The tension in the belt between C and D is laid off graphically at C_1D_1 parallel to CD. The same is done at A_1B_1 for the belt AB. We now lay off O_1R_1 parallel to the hinge rod OR and also O_2E_1 parallel to OE, which represents the weight of the idler. Now measure O_2E_1 from its intersection with O_1R_1 to E_1. This distance measured by the same scale used in laying out A_1B_1 and C_1D_1 gives the idler weight.

Anyone who is at all familiar with graphic statics as applied to the determination of stresses in structures will immediately recognize the principles involved. However, do not permit a lack of familiarity with this subject to deter you. The layout is so simple that it makes little difference whether you understand the principles or not. First make a scale layout of the proposed drive *with the idler in the position which it will take when the belt has stretched until the upper belt almost touches the lower.*

The stresses in the belt AB and CD of Fig. 6 are equal; they are the static tension determined as described above. Lay out C_1D_1 to some convenient scale, parallel to CD and numerically equal to the static tension. Lay off A_1B_1 parallel to AB and *equal to* C_1D_1. OE represents the required effective weight of the pulley and is of course perpendicular to the floor. RO is the hinge rod which supports the idler pulley. Lay off O_1R_1 parallel to OR and draw O_2E_1 parallel to OE. Measure O_2E_1 from intersection to intersection. The length will give the effective weight of idler required, to the same scale assumed in laying off C_1D_1 and A_1B_1.

From this effective weight we must subtract that part of the weight of the two hinge rods and fittings which are supported by the idler. Since these weights amount to a comparatively small part of the total weight of the idler pulley, it will be sufficiently accurate if we deduct from the effective weight of the idler as follows: (1) The weight of the shaft and fittings which clamp it to the hinge rods. (2) Half the weight of the two hinge rods. The result is the net weight of the idler pulley needed.

Example of Computations for an Air Compressor Drive

Let us lay out the drive arrangement for a single-stage air compressor driven by a direct-current motor running at 1,150 r.p.m. The motor starter is of the ordinary manually-operated, resistance type. Rated speed for the compressor is 425 r.p.m. The compressor pulley is 3 ft. in diameter. The manufacturer's bulletin states that 7.2 hp. is required to drive the compressor under our conditions of volume and pressure. The layout for the drive is shown in Fig. 6.

We cannot very well change the compressor pulley; so our belt speed is fixed in spite of us. It is equal to the compressor r.p.m.×diameter (in feet) of compressor pulley×3.1416=425×3×3.1416=4,010 ft. per min. Since our motor runs at 1,150 r.p.m., in order to secure the correct compressor speed the motor pulley diameter must equal [diameter (in inches) of compressor pulley×compressor r.p.m.÷motor r.p.m.]=(36×425) ÷ 1,150 = 13.3 in. Since there may be some slip or creep in the belt we will use a pulley diameter of 13½ in.

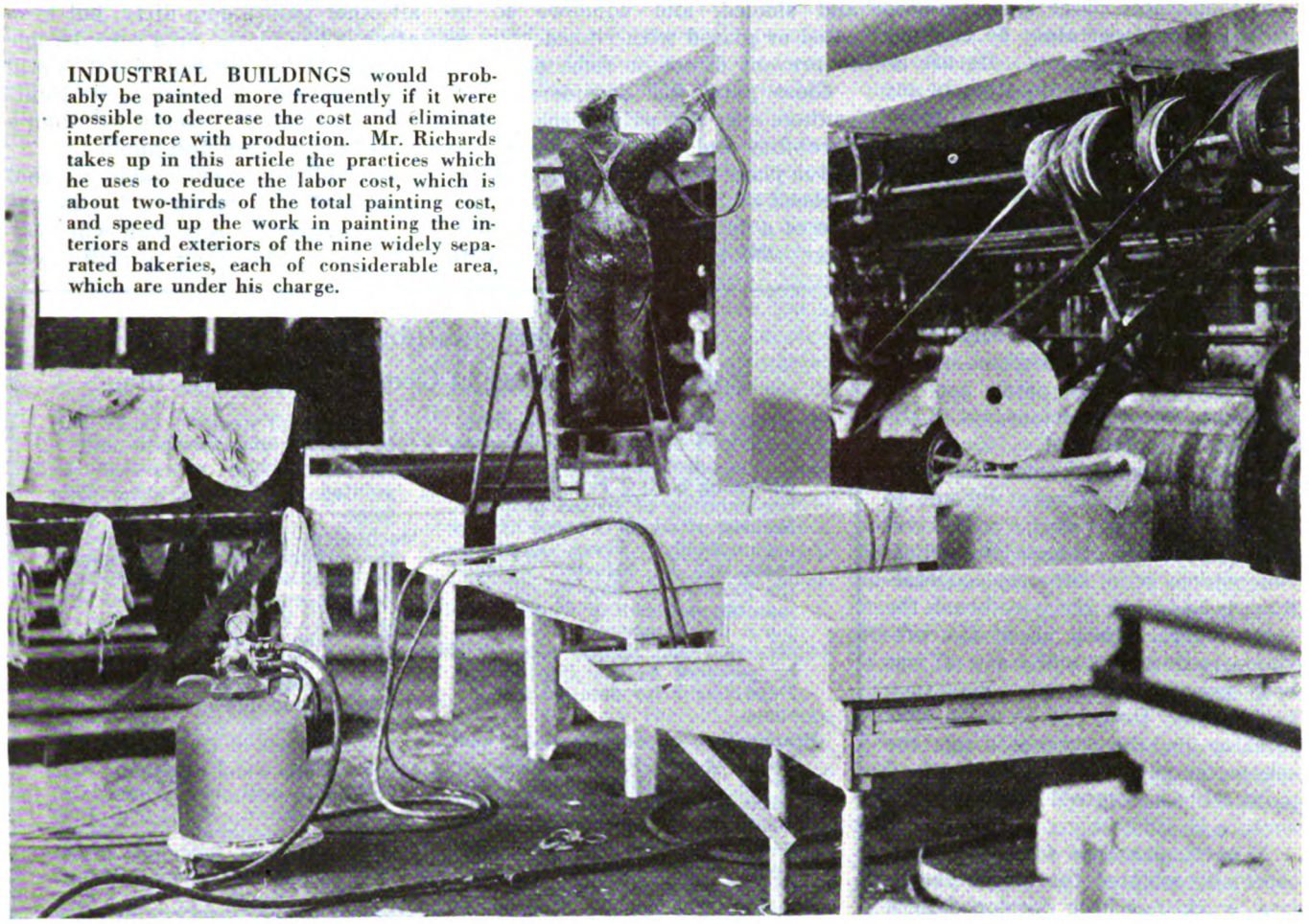
An effective tension of 50 to 60 lb. per in. of standard double-ply belt is suitable for our design (see Table I and notes 2 and 3).

Reference to columns A and B of Table I will show that the effective pull

(*Please turn to page 207*)

**Transactions of the American Society of Mechanical Engineers, Volume 31.

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INDUSTRIAL BUILDINGS would probably be painted more frequently if it were possible to decrease the cost and eliminate interference with production. Mr. Richards takes up in this article the practices which he uses to reduce the labor cost, which is about two-thirds of the total painting cost, and speed up the work in painting the interiors and exteriors of the nine widely separated bakeries, each of considerable area, which are under his charge.

In working around machinery, a stepladder is sometimes the most advantageous type of scaffolding. In cases such as this, it is well to have a helper or two to arrange drop cloths ahead of the painter and remove them after he has passed.

Practical Points to Consider in

Mechanical Painting of Industrial Plants

With a Discussion of the Application and Advantages of Such Painting Together with Specifications for Various Types of Industrial Jobs

By KEENE RICHARDS
Industrial Engineer, Grennan Bakeries, Inc., Detroit, Mich.

CONSERVATION of daylight, particularly during the winter, and the maximum utilization of artificial light emphasize the importance of the proper maintenance of interior painting in factories and shops.

Several different classes of materials, for example whitewash, cold-water paints and oil paints, are available for use in painting the interiors of industrial plant buildings and inasmuch as the selection of the proper material is a matter of considerable importance it will be worth while to consider briefly the advantages and disadvantages of each. First, however, I want to call attention to a fact that is sometimes overlooked: The labor required to apply the paint, the interference with production, and the cost of preparation of the surface are the greatest factors in painting. The cost of the material is approximately only a third of the total cost. Obviously, the cost of the labor and the interference with production are the same whether whitewash, cold-water paints or oil paints are applied. For this reason it would be unwise to use any but the best material as any saving in materials would be overbalanced by more frequent paintings or difficulties incidental to this application.

As a general proposition, the use of cold-water paint or whitewash is not to be recommended. The cost of preparing the surface after the first few coats is much greater when cold-water paint is used; in fact this is its greatest fault, and it is so serious that its use should never be considered except for buildings of the most temporary character.

The writer has found from experience that it is practically impossible to prevent cold-water paint from flaking off. If used on new work it does not penetrate and secure a proper bond; if on old work it flakes continually taking not only the new coats, but some of the old material and often coming off clear down to the original surface.

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If cold-water paint must be used its use should certainly be confined to plaster and masonry. Its use on ceilings is out of the question in any plant handling food or any other material in which the presence of flakes of paint would be objectionable, as any building vibration will be accompanied by a shower of paint flakes of various sizes. Another bad feature is the fact that this difficulty will not show up until the structure has been in use for some time after painting. For this reason several coats of cold-water paint may be applied before the seriousness of the damage is appreciated.

After cold-water paint has once been applied, it is very difficult to apply any covering over it which will stick. The only manner of application which is in any way satisfactory, is to scrape and wire-brush the entire surface until all of the previous coating that will come off has been removed. Oil paint may then be applied. However, if much lime remains on the surface from the cold-water paint, several coats of oil paint will be required before a good surface is secured.

A particular type of white paint especially adapted for use in industrial work, has been developed by a number of concerns. The best type of this paint, I believe, is that with a gloss surface as it catches and retains dirt to a less extent than some other types. A liberal use of paint of this sort will produce wonderful results not only in the appearance of the building but in actual saving of artificial light. Even though white paint shows dirt readily, it is by far the best surface coating for the upper parts of walls and for ceilings.

Various arguments are advanced in favor of the use of cream color, slightly buff or other tinted paints. In my opinion their use is not to be recommended. If the original color could be maintained free from dirt, there might be some advantage in having the paint toned down with some light tint. These paints, however, soon become uniformly dead in color and produce a gloomy appearance with practically no conservation of light. Objection is sometimes made to white paint, particularly of gloss variety, in that it is said to cause glare. The glare is produced primarily by poor or improperly located sources of light. The primary object of the paint on the walls and ceilings of industrial buildings is to reflect all light available. Electric light bulbs should be properly located and shaded, and windows so located or glazed with ribbed glass as to prevent direct or reflected glare.

Gloss paint has considerable advantage over flat paint, especially in durability and ease of cleaning. Its life in place is probably in the neighborhood of 20 per cent greater than that of a flat paint of the same character. White paint in common with all other paints gets dirty, but even after it has picked up a considerable amount of foreign material it is still more efficient, in so far as its light-reflecting power is concerned, than a tinted paint when first applied.

In addition considerable psychological effect is produced by the use of white paint. Any man will hesitate before touching a white wall

Standard Specifications for Industrial Painting at Grennan Bakeries, Inc.

General—The following specifications will be strictly adhered to in the painting of all buildings belonging to this company, or in the painting of rented property, the cost of which is borne by this organization. These specifications will be enforced whether the painting is done by our own maintenance men or whether the job is let on contract. New construction and special cases will be referred to the *Engineering Department* for detailed instructions.

Preparation of Surfaces—All surfaces to be painted must be clean, free from grease, loose paint and rust. It is an absolute waste of time and material to paint over an improperly-prepared surface. New work must be properly prepared by shellacking all knots or creosote stains and in the case of exterior work, by proper priming.

Walls and Ceilings—Rice's Barreled Sunlight (U. S. Gutta Percha Paint Co., Providence, R. I.) will be applied to walls and ceilings. This material will be sprayed on in every case when under contract and on maintenance work in our plants which have the necessary equipment. In the smaller plants or for smaller jobs, it may be brushed on.

Dado—A 4-ft. dado with a 2-in. black strip at the top will be applied after white is thoroughly dry. The white will be carried under the dado only on new work. This dado will be of Lucas brown dado color made by John Lucas Co., Philadelphia, Pa.

Radiators—Radiators will be painted with the same materials as the dado with the exception of ceiling radiators which will be painted white.

Metal Windows—Metal windows will be primed with red-lead primer and one coat of black enamel. Wooden window frames on the interior will receive the same treatment as the adjacent wall surfaces.

Piping—All pipe and conduit, with the exception of the sprinkler system, will be painted the same as the adjacent surface. Sprinkler system will be painted with one coat of red-lead primer and one coat of Lucas vermilion piping enamel. Boiler fronts, water heaters and exposed tanks will be painted with graphite paint.

Fire Doors—Fire doors will be painted with Lucas grey dado color.

Machinery—(a) Machines used in the preparation of our bakery products are painted with Valentine's enamel primer and one coat of Valspar (Valentine & Co., New York City) white enamel. (b) Ammonia compressors, pumps and other miscellaneous equipment receive one coat of Lucas grey dado color and one coat of clear varnish.

Office Walls and Ceilings—Old calcimine will be removed in every instance. Walls will then be sized if necessary and treated with light-buff calcimine, either Alabastine or material of equal quality. Dado will be Lucas brown dado color with 2-in. black strip at the top. Woodwork will be egg-shell varnish; radiators are to match adjacent surface.

Exterior—All new surfaces will be properly prepared and primed; in the case of metal, with red lead; in the case of wood, with white lead and linseed oil. After the priming coat the succeeding coats will consist of two parts of white lead, one part zinc oxide, mixed with linseed oil and not to exceed 10 per cent turpentine. This mixture will then be tinted to the color selected. Fire escapes, metal windows and exterior metal work, which are not to be the same color as the body of the building or trim, will be finished with graphite paint.

Workmanship—No work is to be done on damp surfaces, nor is any exterior work to be done on rainy days or when the surface is in unsuitable condition. The spray method will be used wherever possible as labor ordinarily constitutes about two-thirds of the cost of a paint job. Under no circumstances will cold-water paint be used on any building, equipment or property of this company except as specified for walls and ceilings of offices, unless special permission is secured in writing from the *Engineering Department.*

Purchase—All paint will be ordered from the *Purchasing Department;* the requisition must be approved by the industrial engineer of this company.

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with grimy hands whereas he would not even be conscious of the fact that he had made finger marks on a wall of darker color.

It is not recommended that white paint be carried entirely to the floor. The lower 5 ft. of the wall does not help to conserve light, not only because it is obstructed by machinery and equipment, but because it receives little or no light from windows or the sources of artificial lighting.

In the writer's opinion there is only one way to apply paint and that is by means of mechanical painting by the air spray or gun. This is largely due to the relative cost of labor and material in painting. According to estimates made by *Engineering News-Record* and based on a survey of $400,000,000 worth of new industrial construction during 1924, about $12,000,000 was spent in painting alone. The paint itself would cost about $4,800,000, or a little over a third of the total painting cost; the remainder, approximately two-thirds of the total, was spent for labor, scaffolding and other miscellaneous expenses.

In repainting old buildings the relative proportion of labor cost would probably be higher because new buildings are generally painted before the machinery, stock, supplies or other material are installed. It will require more labor and time, therefore, on a repaint job than on new construction because it is necessary to paint around the machines and other objects and also to clean up any dirty spots before repainting. This would bring the relative costs more nearly to a two-to-one basis. These figures indicate very clearly two things: First, any attempted economy in painting by the use of inferior materials is absurd, as the gross saving is absolutely negligible even if durability is ignored. Second, the big opportunity to lower the cost of painting is in mechanical labor-saving devices. Of these labor-saving devices, the mechanical painting system is the major one.

Organization for Painting Work in Industrial Plants

In the average factory covering 75,000 sq. ft. or more, of floor area, it would be of advantage to purchase a two-gun, motor-driven outfit which can be kept in almost continuous use. This equipment can be operated by moderately skilled labor with a skilled brush painter following up to take care of piping, window sash, and other equipment which may require touching up. It will be found when this equipment is first installed that a slightly greater quantity of paint will be used but as the operator becomes skilled there will be a considerable saving. The gross saving over hand work should be at least 25 per cent. Other savings can be made which are somewhat indefinite, such as a decrease in the amount of scaffolding required and through the ability of the paint gang to go through various departments during the periods when they are shut down either at night or on holidays.

Where an industrial organization consists of a number of small plants located in different cities, it is better to purchase smaller units of equipment of perhaps only one-gun capacity for each plant, rather than to attempt to use larger units of equipment and ship them around among various plants. It is only by taking advantage of slack periods in various departments and by doing painting at exactly the best opportunity that the maximum saving can be made. If it is necessary to ship the equipment this result cannot be obtained.

Of almost as much importance as the proper selection of equipment and paint is the proper handling of scaffolding and drop cloths. The provision of a sufficient number of these enables one or two laborers to keep this equipment set up ahead of the painters and take it down behind them so that the men actually doing the painting can keep going without interruption.

As in any other painting job, the most important part is the preparation of the work. If this has been done correctly when the surface was first painted, comparatively little preparation is required before spraying. It is not the intention of



Two ways to help the speeding-up of industrial painting.

Here a paint spray is used on the interior brick wall of a building. This work is speeded up considerably by the portable scaffold and also the special and easily-constructed device for holding drop cloths over the windows to prevent paint getting on the glass. It will be noticed that the brush painter has preceded the spray operator and has touched up around the windows and other places which would be covered up by the drop cloths. The construction of this platform, which is on casters, and also the frame for holding the drop cloths over the window, is easily seen from the illustration. The paint container is also mounted on wheels. The compressor is not shown here.

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this article to emphasize well-known requirements of good painting. However, it is important that knots, sap and similar defects in wood, as well as scale, pitch spots and the weakness of other materials be properly taken care of.

One of the best methods I have found of sealing up an unsatisfactory surface, such as one that has had creosote applied to it or some stain which works its way through white paint, is to paint it first with aluminum bronze. This will effectually seal up the surface ready for final work. Bronze paints should be applied preferably with a brush.

While the air gun method is used in painting parts of machinery, equipment, automobiles, furniture and other products in production work, it has some limitations when applied to buildings. The simplest surface to paint, of course, is that of a wall or ceiling unobstructed by piping, shafting or other equipment. This sort of surface is, however, seldom met with. The most economical way to paint an obstructed surface is to go right through with an air gun, ignoring the smearing up of piping which is bound to occur. The gang can then be followed up by men with brushes or in the case of large piping, with a small-nozzle gun to touch up the piping.

Some Suggestions on Painting Pipe Lines

The question of pipe color is discussed in a paragraph in the accompanying standard painting specifications. The brush men, whenever possible, should work on the same scaffold with the men handling the painting equipment. This is frequently impossible, however, and as the brush men merely touch up they often work from an ordinary stepladder, without scaffolding. The illustrations show very well some types of scaffolding and drop cloths which have been found desirable. In addition, it is important that men using the spray method be equipped with a simple type of respirator to prevent the inhalation of paint fumes. The material is in a finely divided state and may cause serious illness if this precaution is not taken.

It is of great advantage to have standard specifications issued for each building, covering exactly the kind and quantity of paint to be used on each class of equipment as well as on the building itself. A sample of the specifications used by this company to cover painting of a factory handling food products is given elsewhere in this article.

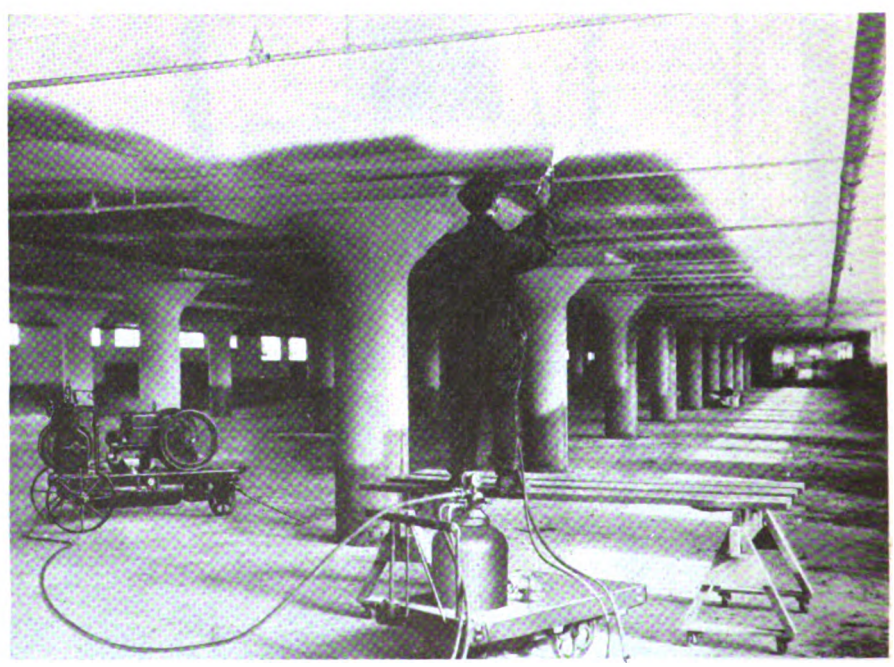
In some instances it is best to classify pipe lines by color, although I believe that this is frequently overdone. With the exception of fire protection lines and pipe lines carrying dangerous liquids or gases it is believed that piping had best be painted the same color as the adjacent structure as it may then be run in with the sprayer without hand work.

If it is desired to combine the advantages of marking as well as spraying pipe lines, conduits and similar structures the pipe line color scheme may be carried out by running it in with a brush, by painting valves or couplings on uncovered lines, or painting bands around covered pipe lines. If this is done the men spraying should skip these bands sufficiently so that the original color will be visible for the man who is to follow up and run them in with the brush. This work must be very carefully checked up, as there might be considerable danger in the use of the wrong color on a line carrying ammonia or other dangerous liquid or gas. This system has been used in a number of central stations and has proved highly successful. As an additional factor of safety it is advisable to tag important valves on lines carrying high-pressure steam, ammonia or other dangerous gases or liquids.

Problems Incidental to Washing Painted Surfaces

While practically any good mill white paint will stand washing it will be found in the majority of cases that the cost of washing is in excess of the cost of repainting by mechanical methods. The labor cost of washing is higher than the labor cost of spraying and the cost of the necessary cleaning solution plus the extra labor will closely approach the cost of paint. The appearance of a cleaned surface does not, of course, approach that of a repainted surface. In some instances, it is necessary to clean and repaint both, as the surface may be in such condition that a satisfactory repainting job is impossible.

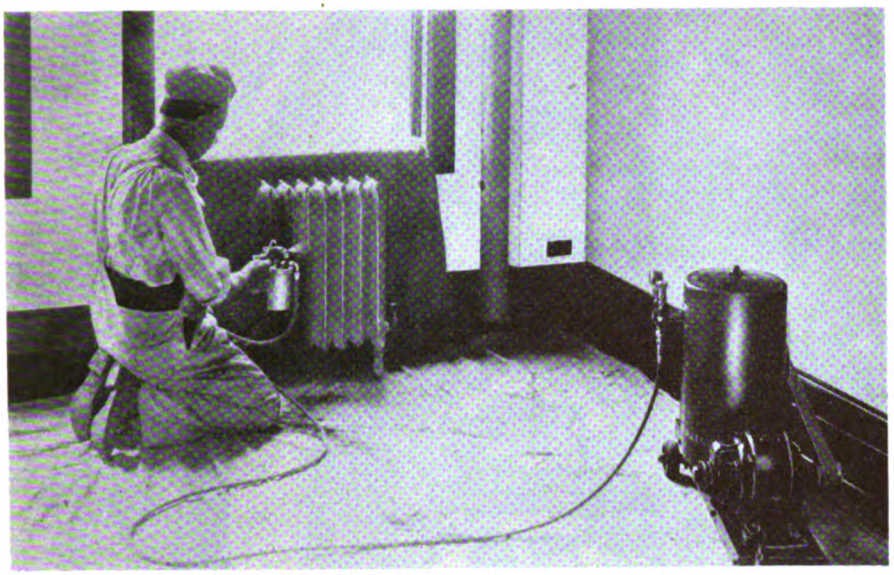
A solution of common washing soda or any of the neutral soda compounds on the market such as Wyandotte Cleaner (J. B. Ford Co., Wyandotte, Mich.) are very good for general cleaning of paint work. Strong caustic alkali solutions must be avoided as they will remove not only the dirt but the paint, as well. In the case of very old paint it will probably be necessary to use a solution of sufficient strength to remove a thin film of paint in order to clean the surface.



Painting the ceiling of a new concrete building.

Notice the ease with which this entire equipment may be moved. The platform is constructed of the proper height for the painter and the wooden "horses" are put on casters. The paint container is placed on a truck so that it also can be easily moved. Even the compressor, which does not have to be moved so much as the other equipment, is also portable. Whenever possible, it always pays to paint a building before the machinery and other equipment are installed. Here the sprinkler lines and other pipes are in and may be painted by the spray or left for touching up by hand as desired.

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How a small painting unit is used for follow-up work.

Motor-driven compressor units, such as this, with a small single-gun outfit, are used for painting radiators, pipe lines and for other follow-up work, as well as in small plants which do not require a larger unit. Here the paint is stored in a small container near the gun. Notice particularly how the wall and floor are protected by drop cloths.

The great danger in using a cleaning solution is that it may not be properly rinsed off and that it will continue to act on the paint after painting is completed. Different conditions involve different cleaning solutions. It will be found in some plants that a coating of a definite chemical compound will be formed on the paint due to the nature of the processes in the plant. When this is found to be the case, the best way to lessen the necessity of repainting too frequently is to provide adequate ventilating equipment at the source of air pollution.

Many states require that hoods and suction lines be used in connection with all machines or processes causing or generating dusts or fumes detrimental to the health of the workers. That this has other than health advantages is easily seen.

While this equipment may be expensive in first cost it can soon be charged off, due to the great saving in painting costs through less frequent repainting, and also through the increased illumination due to the better reflecting value of a painted surface which is not covered with dirt. This removal of obnoxious vapors must not be confused with general ventilation. In fact, general ventilation is often responsible for paint discoloration as it tends to spread any fumes before removing them from the building. A satisfactory job of painting cannot be done on a surface which has been coated with material of this sort, particularly if this material is a paint repellant.

In many industries it is necessary to wash paint frequently for sanitary reasons. This washing will generally be required only on the lower 6 ft. of the wall. Where this is the case a dado should be painted of a high-grade, water-resisting paint or the ordinary wall paint may be used and this dado given a coat of spar varnish. In these buildings it is much more satisfactory to have this wainscoting made of white enamel brick, tile or glazed brick as no paint will stand the frequent washing required in factories handling food products. The necessary number of such washings may be decreased by placing machinery and equipment a sufficient distance from the wall to prevent spattering.

With the labor cost such a high percentage of the cost of paint, emphasis must once more be placed upon the desirability of using not only good, but suitable material. Cheap paints contain inert, inactive and useless material of various sorts which cause the surface to break down and discolor rapidly. In addition, good paint improperly used will give poor results. Paints subject to fumes of a chemically active nature should be of the so-called chemical or fume-proof variety which are put out by a number of reputable manufacturers. The use of this type of paint, however, must not be misunderstood. While fume proof to the extent that the paint itself will not combine with gases and discolor, they are, of course, not proof against the accumulation of mechanical coatings which give the effect of a discoloration. These coatings can be removed by cleaning, whereas another type of paint unsuitable for this use would in itself undergo a chemical transformation so that no amount of cleaning would restore its original color.

Why It Does Not Pay to Use Poor Quality Paint

As an example of good and properly selected paint, I have in mind two roof ventilators erected at about the same time and subject to the same atmospheric conditions. One was painted with red lead, the other simply with black paint. Since no specifications were furnished the paint was presumably nothing more than lampblack with a binder of some sort. Neither ventilator received any further attention. At the end of three years the ventilator covered by black paint was completely rusted and required replacing. The ventilator which had been painted with red lead appeared to be in as good condition as when first erected. This is rather an extreme case perhaps as it involved not only the replacement of the paint, but the entire replacement of the equipment in addition. The cost of the red lead over the black paint amounted to only a few cents. The cost of the new ventilator was about $45. In this connection it might be said that the use of the paint gun is one of the best methods of painting structural steel, the intricate details of which are sometimes very difficult to reach with a brush.

The writer has formed rather definite opinions as to various brands of paint available for interior and exterior use and is absolutely convinced there is no better way to spend money than on high-quality ingredients. There are a large number of excellent brands of paint on the market and the purchaser can make no mistake in purchasing any one of these reputable brands. Hand-mixed paint, at least in so far as required for industrial work, is a thing of the past, as it is absolutely impossible for a painter to properly mix the ingredients on the job by hand. Most paint manufacturers have a service department which will be glad to take up in detail any particular problems which may arise. This service should be freely used by industrial men.

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COILS THAT ARE diamond shaped as well as those consisting of straight bars connected by involute end connectors are used in turbo-generator windings. Both kinds of coils are shown in the accompanying illustrations together with typical winding diagrams showing how the coils are connected to form the completed winding.

Methods for Taking Data on

Turbo-Generator Windings

Together With a Description of Single-Layer, One-Bar-Per-Slot Windings and Two-Layer Lap Windings as Used on These Machines

By A. C. ROE

Renewal Parts Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

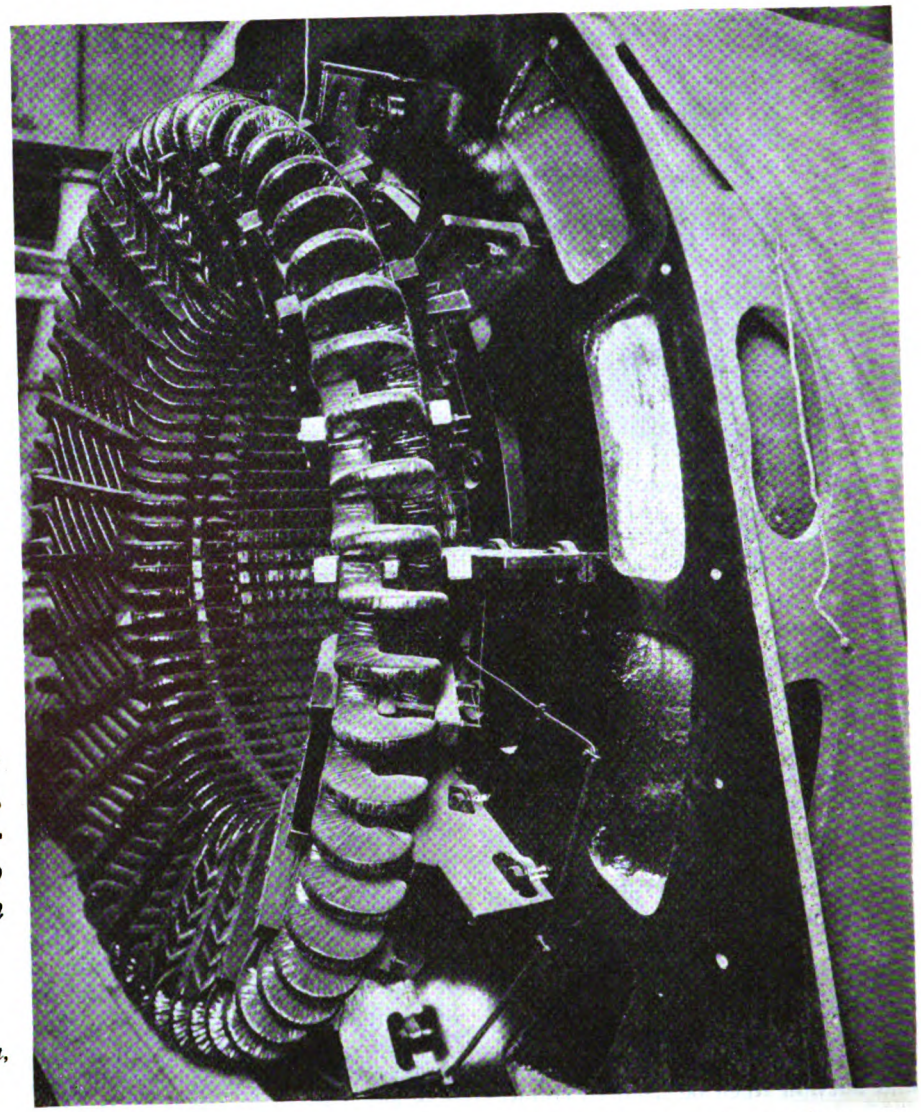


Fig. 1—Showing the method of bracing used on a turbo-generator winding.

The end turns are held between insulated braces which are bolted together and to the stator of the machine. This is necessary in order to protect the end turns from torsional strains set up by short-circuits that may occur on the machine. This illustration shows the rear end of the winding, which has no group or phase connections.

IN THE two preceding articles of this series we have discussed one-coil-per-slot lap and wave windings, as well as one-bar-per-slot wave windings. In this article, we will take up one-bar-per-slot lap windings. These are mostly used in turbo-generators. Inasmuch as turbo-generators are also wound two-layer in the slot section, we will also consider this method of winding.

Turbo-generators generally use diamond-shaped coils, consisting of two half-coils, each half-coil being composed of one slot section at the two ends of which are the end pieces. Another type of coil used in the smaller turbo-generators uses an involute end connector.

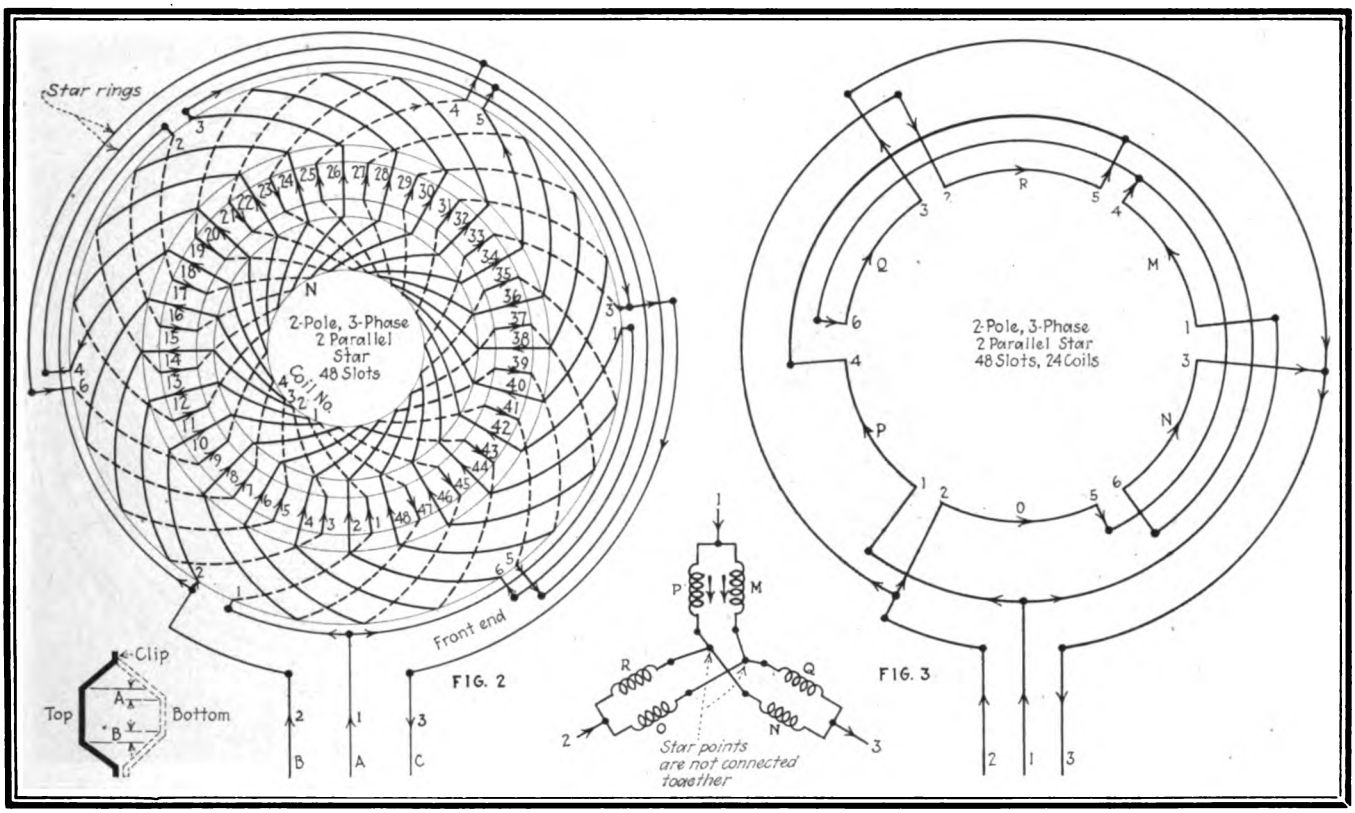
Let us first consider a single-layer, one-bar-per-slot winding, as applied to a two-pole, turbo-generator stator. In Fig. 2 is shown the connection diagram for a 48-slot, two-pole, three-phase stator having 24 coils; that is, there are 24 long half-coils and 24 short half-coils. The ends of the half-coils are placed in two layers; that is, the ends of the half-coils having the short slot section will underlie the ends of those having the long slot section. The ends of the half-coils are joined together with clips and soldered and insulated as shown in the sketch at the lower left of Fig. 2.

In a lap winding of this type, the number of pole-phase groups equals the number of poles multiplied by the number of phases, which in the winding under consideration equals $2 \times 3 = 6$ pole-phase groups. The number of coils per pole-phase group is equal to one-half the total number of half-coils divided by the number of pole-phase groups which, for this winding, will equal $(48 \div 2) \div 6 = 4$ coils per group.

In this type of winding the full back pitch must always be odd and equal the odd number nearest to the quotient of the total number of half-coils divided by the number of poles. Since there are 48 half-coils and two poles and $48 \div 2 = 24$, the full back pitch for the winding will be 23 or a pitch of 1-and-24. However, the back pitch generally used runs from 50 to 70 per cent of the full back pitch; hence for this winding the

WINDINGS HAVING one coil per slot and one bar per slot were discussed in the first two articles of this series, which were published in the January and March, 1925, issues of INDUSTRIAL ENGINEER. In this article, Mr. Roe takes up one-bar-per-slot windings as used in turbo-generators and also describes and gives the diagrams for two-layer windings that are often used in these machines.

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back pitch will be $0.50 \times 23 = 11.5$ or a pitch of 1-and-12.

Let us start the A phase of this winding in slot *1*, as shown in Fig. 2. Using a back pitch of 1-and-12, the winding will continue from slot *1* to slot *12* and thence back to slot *3*; then through slot *14* and back to slot *5*, from which it goes to slot *16* and back to slot *7*. It then goes to slot *18*, after which it goes to the star point. In going through this much of the winding, we have traveled through a series of four coils, which forms a pole-phase group.

In putting the arrows in this diagram the two-in-and-one-out check is used, as has been explained in previous articles. In Fig. 2 line leads *1* and *2* are taken as going in and line lead *3* is taken as coming out. This scheme is followed throughout this diagram. The arrows are also inserted in this manner in Fig. 3, which is a line diagram for the winding shown in Fig. 2. In Fig. 3 the pole-phase groups are marked *M*, *N*, *O*, *P*, *Q* and *R*. The polarity of the pole-phase groups can be checked by the two-in-and-one-out check.

In Fig. 3, the beginning and end

Figs. 2 and 3—Here are the diagrams for a one-bar-per-slot lap winding used on a turbo-generator.

Fig. 2 shows the complete winding diagram for this machine. The phases are connected to form two independent star connections with the line ends connected in parallel. Fig. 3 shows the line diagram for the same winding. In this diagram, the pole-phase groups are indicated by the arcs M, N, O, P, Q and R. At the lower left of Fig. 3 is a simplified diagram showing how the groups M, N, etc., are connected two-parallel-star.

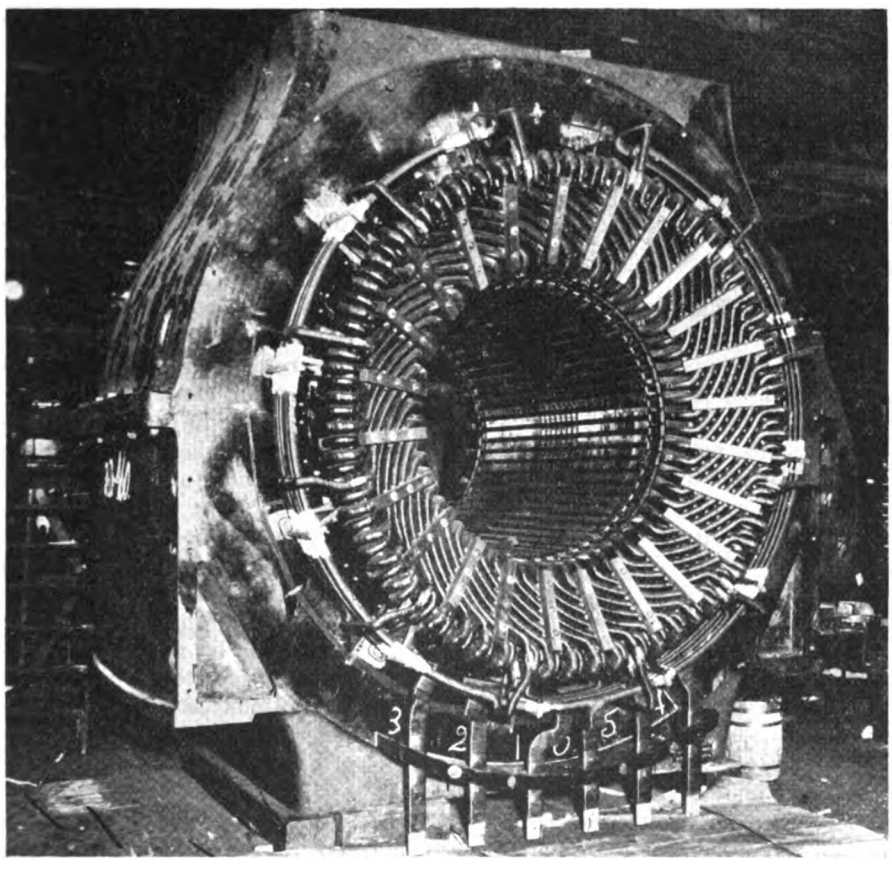
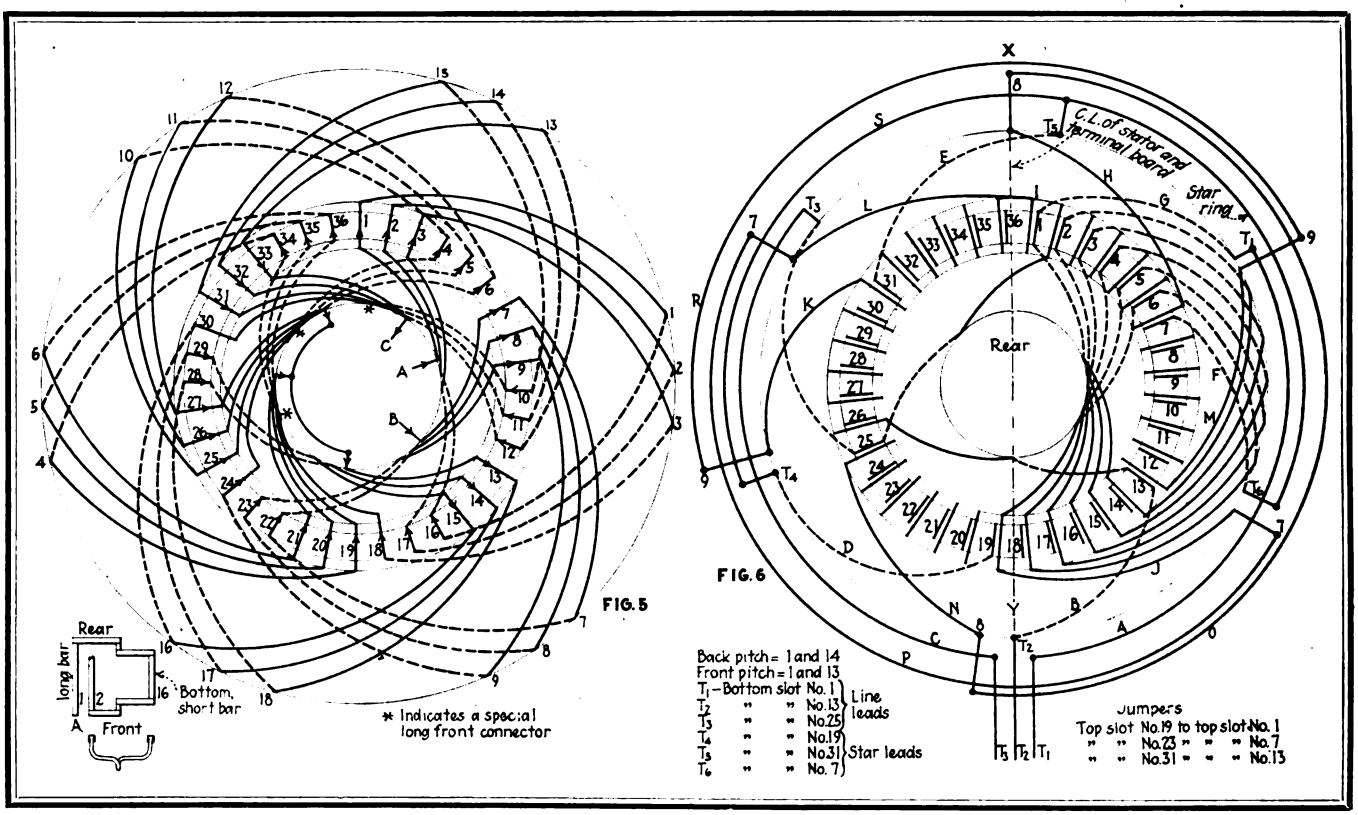


Fig. 4—The manner of making the connections between pole-phase groups can be clearly discerned in this illustration.

This turbo-generator has a two-layer lap winding using diamond-shaped coils. Further details of the connection scheme for this kind of winding are shown in Fig. 6. Notice the marking used to lay off the winding. Careful inspection will show that coils 46, 51, 58, etc., are marked with their numbers; also the leads are marked 1, 2, 3, etc.

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of each pole-phase group is marked with a connection number which corresponds to the connection number at the beginning and end of each pole-phase group in Fig. 2. This is done to identify and locate each connection. In this type of winding the connectors are made of bar copper bent on edge in a ring shape. These rings are supported by brackets which are fastened to the stator frame. Specially-shaped connectors are used to make the connection between the coils and jumpers; hence the need for some means of locating each connector with reference to its ring and slot.

At the lower left of Fig. 3 is shown the schematic diagram for this winding. The pole-phase groups in this diagram are lettered to correspond with those in the main diagram. Inspection will show that the winding is connected two-parallel star. However, the pole-phase groups are not directly paralleled, but one set of three pole-phase groups is connected to form one star and the other set of three pole-phase groups is connected to form the second star. The line ends of the two star connections are then connected in parallel.

In the second article in this series, published in the March, 1925, issue of INDUSTRIAL ENGINEER, wave-wound, one-bar-per-slot windings were discussed. Before considering the two-layer, lap-wound, turbo-generator windings, we will digress for the moment and take up lap-wound, one-bar-per-slot windings having involute end connectors. With the exception of the end connectors, this winding is quite similar to the windings that we have just considered.

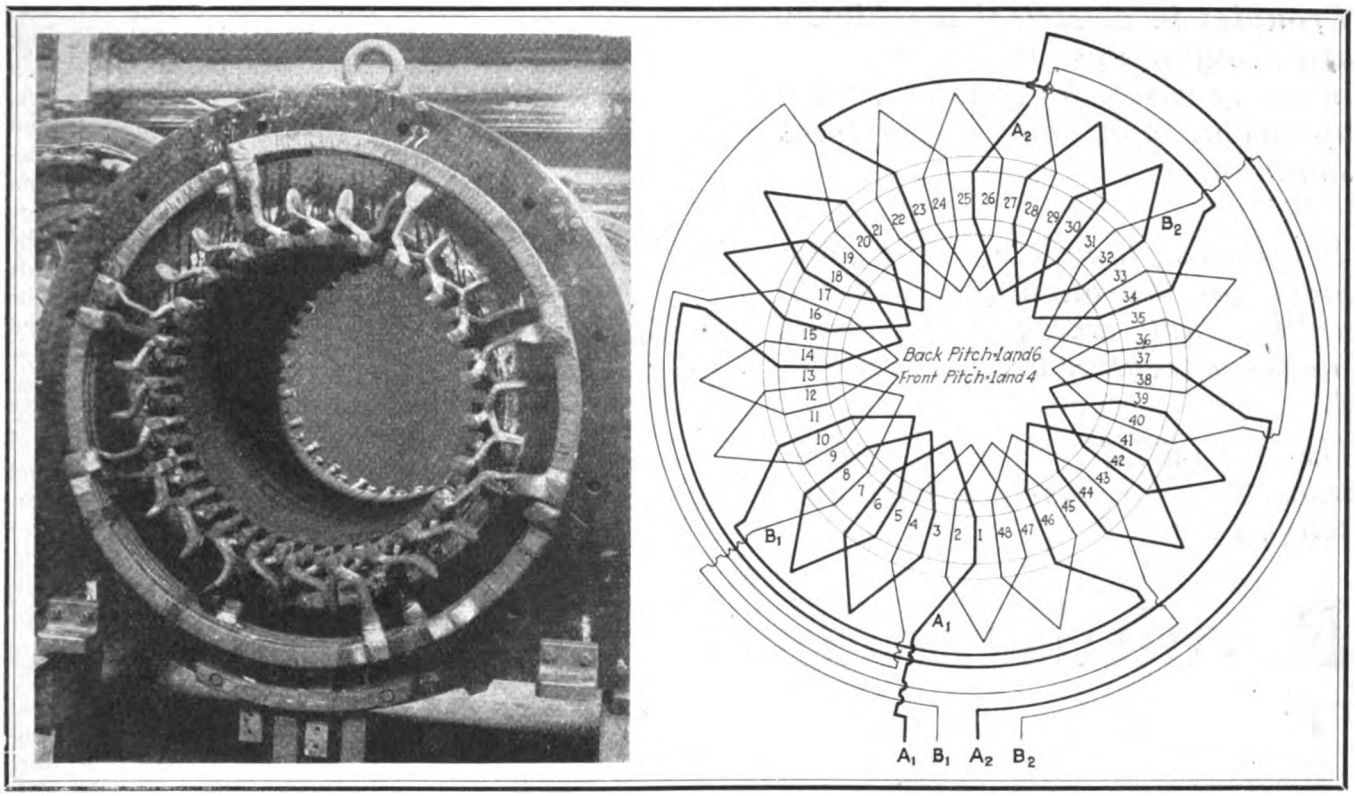
Figs. 5 and 6—Study of these two diagrams will give a clearer understanding of one-bar-per-slot lap windings and two-layer, lap-wound, turbo-generator windings.

In Fig. 5 is shown a one-bar-per-slot lap winding for a 300-kw., two-pole, three-phase, 60-cycle machine having 36 slots. Involute connectors requiring three ranges are used for making the end connections. The third range, which has the extra long bar, is used only for making the connections between pole-phase groups. The phases of the winding are connected in series-star. Fig. 6 shows a two-layer lap winding for a 2,250-kva., 4,600-volt, two-pole, 3,600-r.p.m., three-phase, 60-cycle, turbo-generator. Thirty-six diamond-shaped coils, which are made up as half-coils, are used in this winding. The letters in the diagram indicate the 17 different sizes of connectors and rings that are required for making connections between coils.

Such a winding is shown in Fig. 5. The A phase is started at the front end of the bar in slot *1*, and goes through the bar in slot *1*, which is connected at the rear to the bar in slot *16*. The back pitch is, therefore, 1-and-16. The method of making the involute end connection between bars *1* and *16* and between bars *16* and *2* is shown at the lower left of Fig. 5. The front end of the bar in slot *16* is connected to the front end of the bar in slot *2*; the rear end of this bar is connected to the rear end of the bar in slot *17*, the front end of which is then connected to the front end of the bar in slot *3*. The rear end of the bar in slot *3* is connected to the rear end of the bar in slot *18*. It can be readily seen that we have gone through a series of three coils which started in slot *1* and ended in slot *18*. This series of coils constitutes a pole-phase group. It will also be noticed that the bars in slots *1*, *2* and *3* are long bars whereas the bars in slots *16* and *17* are short bars. The top halves of the involute end connectors connect to the long bars and the bottom halves of the involute end connectors are connected to the short bars.

It now remains to connect the pole-phase group, through which we have just traced the winding, with the second pole-phase group for this phase. Inspection of the diagram will show that the bar in slot *18* must be connected to the bar in slot *34* by a pitch of one slot more than the regular front pitch. The bar in front of slot *18* is an extra long bar and is connected by means of an involute end connector to the front end of the bar in slot *34*. The winding continues through the second pole-phase group for this phase, through slots *34*, *19*, *35*, *20*, *36* and *21*. The front end of the bar in slot *21* is connected to the star point. The

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winding for the B and C phases is connected in a like manner, the extra long bars falling in slots *24* and *30*, respectively.

In taking rewinding data on this type of winding, care must be exercised to mark the slots which contain the special bars and also the slots to which the leads connect. The winding data is taken as follows:

(1) Call any one line lead A_1.

(2) Mark the slot to which the lead connects as slot *1*.

(3) Counting clockwise, the data would be as follows:

(a) The line leads will connect to long bars falling in slots *1*, *7* and *33*.

(b) The star connectors will connect to long bars falling in slots *13*, *21* and *27*.

(c) The extra long bars will fall in slots *18*, *24* and *30*.

(d) The special, long-pitch, involute end connectors will connect together the bars in slots *18* and *34*, also the bars in slots *24* and *4*, and the bars in slots *30* and *10*.

(e) Starting with slot *1*, the distribution of long, extra long and short bars will be as follows: 3 L, 3 S, 3 L, 3 S, 3 L, 2 S, 1 EL, 3 L, 2 S, 1 EL, 3 L, 2 S, 1 EL, 3 L, 3 S. In the above S refers to a short bar, L refers to a long bar, and EL refers to an extra long bar.

(f) The back pitch will be 1-and-16.

(g) The front pitch will be 1-and-15.

(h) The special front pitch used in connecting the extra long bars will be 1-and-17.

By marking the slots and recording the data as shown, it will be found that a wiring diagram will not be needed. When marking the core, mark the teeth on either side of the slot that is desired to be located. Also, check the line of the center lead with the core, that is, the center line of the terminal block. The winding that we have just discussed gives a good appearance and is easy to connect and wind.

Figs. 7 and 8—Lap winding for a two-phase turbo-generator having one bar per slot and using involute end connectors.

Fig 7 shows the arrangement of the bars, the involute end connectors, and the group jumpers, which are the bar rings surrounding the winding. Fig. 8 shows the winding diagram for this machine. One phase is drawn in heavy lines to enable you to check the circuits more easily. It will be noticed that the machine has 48 slots and bars, four poles, six slots per pole per phase, and three coils per group.

A one-bar-per-slot lap winding using involute end connectors, as applied to a two-phase turbo-generator, is shown in Figs. 7 and 8. Fig. 7 shows the arrangement of the bars and the involute end connectors. The group jumpers are the bar rings that surround the winding. In the winding diagram for this machine, which is shown in Fig. 8, one phase is drawn in heavy lines to enable you to check the circuits more easily. It will be noticed that the machine has 48 slots and bars, 4 poles, 6 slots per pole per phase, and 3 poles per group.

We will now take up two-layer windings as used in turbo-generators. Such windings are lap wound, using diamond-shaped coils, each coil consisting of two half-coils. In Fig. 4 is shown the connection end of such a winding for a turbo-generator. The circular rings that are made of heavy bar copper and encircle the end of the winding, are used for making the lead and jumper connections. The rear end of a turbo-generator winding is shown in Fig. 1. In both of these figures, notice the method of bracing that is used to hold the end turns of these large coils in place. This bracing is required to keep the end turns from being twisted in case the machine is short-circuited under load.

A working diagram for a 2,250-kva., 4,600-volt, three-phase, 60-cycle, two-pole, 3,600 r.p.m. turbo-generator is shown in Fig. 6. This machine has 36 slots and 36 coils which are two-layer lap wound. In this winding, the phases are connected series-star, a progressive winding being used. Only one full phase group is shown connected in the diagram. However, the line leads, star leads, and jumpers are all shown.

Reference to Figs. 4 and 9 will show that the terminals of the machine are located at the bottom and center of the stator. This location is used in the diagram in Fig. 6. The vertical center line of the machine passes through the center terminal and between slots *18* and *19* and slots *36* and *1*.

(*Please turn to page 209*)

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Troubles in electrical machinery are peculiar unto themselves, for in many cases the causes are not apparent and only symptoms show up.

* * *

These symptoms call for a complete and thorough diagnosis not unlike that which a physician makes in treating his patients.

* * *

Our friend Ed tells us in this article how he has handled some tough cases.



Reminiscences of a Trouble Shooter for a Machinery Builder

Sketches from an interview by

Practical Pete

IN THE March issue, I related some of the things friend Ed told me in a recent interview about his job as an inspector for a large machinery builder. In this article I shall continue our discussion of the things talked about and refer particularly to some troubles that Ed brought up because they called for some fast thinking, some ingenuity, and a lot of common sense. I will pick up the thread of our conversation at the point where it was cut off in the March issue.

"From your experience as a trouble shooter, Ed, you must have formulated some rough-and-ready rules on what to do first on a trouble job when the symptoms are puzzling and do not clearly indicate the cause or location of the difficulties. Let's have some of those experiences," I suggested.

"Well, I guess that's so," said Ed. "But just how to lay down rules of procedure is a hard thing to do, for 'most every trouble is searched out by a process of investigation and elimination of this or that possibility until the vital spot is located. It takes experience and a practical knowledge of the apparatus you are working with to know just what to do first. I can probably best illustrate what I mean by some more details of my own experiences on particular jobs.

"Thanks to an old timer, I learned two things at the beginning of my electrical work that are very often true in diagnosing trouble. The first axiom of this particular old timer was: 'Remember that 90 per cent of electrical trouble is mechanical.' His second one was: 'Beware of simplicity in looking for trouble.'

"I really believe that his first axiom is generally true, for I have often spent much time and trouble and have seen others do the same, trying to fathom the intricacies of electricity from the fundamentals to Steinmetz, only to find the trouble in a mechanical area. To cite an instance, I recall my first erection job. It called for the installation of a generator (three-phase, 2,300 volts), switchboard, and three-phase, 2,300-volt transformers to parallel with a two-phase 460-volt outfit. I was instructed by the office to have everything in readiness for a test run to be supervised by an older engineer who happened to be in that territory. The heat-run for drying out was completed and I was just making connections for phasing-out when this engineer arrived on the scene. He made a number of inquiries and we went over the installation in detail to the point of phasing-out, when he asked if I had noted the voltage delivered on the low side of the transformers for the new job. This I had not done, but we brought the outfit up to synchronous speed and took the most unbelievable readings possible to take. I do not recall what they were at the present time, but an unbalanced condition existed of about 150 volts in the phases and much more than that between phases.

"I was distracted and 'all in' after a fatiguing drying-out run and the supervising engineer was also puzzled, to say the least. Between the two of us we thoroughly analyzed the board, the machine, and the transformers, but not a thing was found to create a suspicion of the trouble. Doubtful questions were brought to the attention of the office engineers, but this did not help us in the least. Here was a prize jinx if there ever was one.

"This engineer had arrived about 10 o'clock in the morning. About 6 o'clock that night while making another examination of the switchboard, we discovered after removing the short-circuit wire immediately above the oil switch, that one of the outgoing lines to the transformer had not been reconnected to the switch, with the result that the transformer was being fed by only two wires from the generator. It was at this point that I was working when he arrived on the job. A fatigued body and an excited brain account for the oversight that commanded a whole lot of attention for over a half-day. All of this brings the first, if not both, of Old Timer's axioms to the front. As an indication of how the supervising engineer felt about the matter, I might relate that he took it good naturedly with the exclamation that, 'The drinks are on me.' Whether or not he discovered that I knew at least a few electrical terms, or had used this as a bribe to keep the account of our trouble and his half-day worry from other engineers, I do not know, but he turned in a very good account of the installation."

"But," said I, "not all electrical troubles can be traced to mechanical faults of operation or construction. How about the human errors of over-

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sight and just natural mistakes in following blueprint connections?"

Ed thought a minute and then said:

"If a trouble shooter or service man keeps the first axiom in mind it is very unlikely that the second one will bother him, but it has tripped me on different occasions and it was on one of these occasions that a man of little training discovered the error. One instance was in connection with a bad board. This board was of the automatic type, controlling a large synchronous motor. During the course of erection, I found the blueprint and the board at outs and I was practically at outs with both of them. It was a rush job. The ever-present officials were present accompanied by others from district and general offices and it was hot and dirty, and everything was about as 'cockeyed' as it could be.

"It is my plan to wire according to the blueprint. If it is wrong I cross my bridges when I get to them. If it is right, I feel happy. This I had done in this particular case and when the starting button was pressed I expected most anything to happen. It did! The most silent board I ever saw looked me in the face, as did every official, looking more officious than ever. I left the juice on the board and tried out various relays which were OK, as individual units. This did not help much; so I began at the starting button to trace out trouble and I can truly say that I never did see such a mixed-up outfit. It was during my survey of the trouble that the company electrician began an investigation and at the starting button found a wrong connection. This button was so designed that it had two entrances with a cross-connection necessary for use as a single connector. I had passed up that item, due to my knowledge of what I could expect from such a board as learned in its erection. Nevertheless, it is the little item such as this one that is more than likely to trip up the service man and not the practical chap who cannot see beyond points close to his nose. This is no reflection on these chaps, for the great majority are the best of fellows."

"Now, here's a touchy point, Ed, that comes to my mind in connection with these mechanical troubles, on which I should like to get your comments. In running down troubles charged to the equipment made by your company, you must have bumped into troubles in other makes of equipment used with yours that were either the real or a contributing cause of the trouble you were called to remedy. In such a case just how do you proceed?"

"Such cases come up frequently," was Ed's reply. "Such a mechanical trouble comes to mind in connection with a new installation for a large manufacturer who had installed an automatic station for charging batteries in his fleet of trucks. This firm had purchased an automatic board from a reputable manufacturer and a motor-generator set from our firm.

"The switchboard was erected by the customer, and when it came time to test them out, there was no service—rather, I should say, there was peculiar service. The motor would at times attempt to start and the board would attempt to function, but on only one occasion out of numerous attempts did both of them function correctly and then the service was of very short duration, for the motor stopped. Further attempts were useless. The switchboard men claimed their product was OK, and blamed the motor.

"The above information on the case was given to me on my arrival. A talk with the switchboard men disclosed the fact that they evidently knew their board and it was correct as far as they could tell from the blueprint and their experience. I made a casual inspection of the motor and generator, but nothing appeared out of the ordinary. Further starting attempts were made and we were fortunate in getting an attempt to work, with the usual stop. This was sufficient to form an idea in my mind, from what had been related and the short observation I had made, that we were enjoying a loose contact somewhere on the d. c. end of the motor-generator set or the connections of this set to the switchboard. Tests were made and a loose connection was found in the shunt field. The wire was in its keeper, but the retaining screw had never been tightened at the factory. Paint from the spray gun had lodged in the opening, serving to insulate it, with the result that no excitation was apparent at the switchboard for the operation of the board.

"Here is another mechanical ailment which has to do with a manufacturer and his apparent trouble with a small auxiliary generating set. This set operated from the time the works closed at night until work was resumed in the morning, during Sundays, holidays, etc. It served to keep the sprinkling system from freezing, to provide night lights, and to operate the machine shop air compressor and other auxiliaries which included a number of fans. The generator rating for this output was barely enough to handle the load, but according to the manufacturer it would do so. Various load tests on individual units and circuits were made and the outfit behaved badly. As a matter of fact, it would be unsafe to leave this large woodworking plant to depend on this outfit to keep its heaters in proper service in the event of extremely cold weather.

"Load tests brought us to the output test and we soon found the trouble to be insufficient steam pressure to develop the full power of the prime mover. The pulley was too small, with a correspondingly small belt to transmit the power, with unnecessary apparatus on the pulley shaft resulting in too much friction load. To end this incident a larger set was recommended."

"Another kind of trouble," I remarked, "that seems to me you have to handle more as a diplomat than as a trouble shooter, are those cases where the operators are sure that the troubles are not due to changes or repairs that they have made. Tell me how you have handled some such situations."

"A very frequent trouble of this nature has to do with interpoles," Ed replied. "Wrong connections are easily discovered on the test floor of the manufacturer and are quickly corrected. But many times the customer desires to make changes in his machines to take care of some particular operation of his own and, as a consequence, changes his motor to suit the requirements. The results are like the situation presented to me last fall. After such a change was made, the usual trouble of reversed interpoles presented itself and efforts were made by the electricians to correct it, with unsatisfactory results. Correspondence with the manufacturer followed, but the trouble persisted and it was finally decided to call in the service man. The plant men insisted that they had done everything to correct the trouble, and from their explanation it seemed as if they were right.

"An investigation, however, showed that they had merely changed the

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connections of the interpoles and had not reversed them. The simple test to discover the facts for this motor was to run it as a series motor and note the rotation. This had to be done with care as excessive speed is only a matter of a few seconds. The series connections were then removed and it was tried out as a shunt motor, in which case the direction of rotation must agree with that of the series connection. If it does not agree, reverse the connections until it does agree. Then connect as a compound interpole motor and check the polarity of the interpoles with a compass or with a piece of iron. The relation of the interpoles to the main poles in a motor of clockwise rotation is such that when the main pole corresponding to 12 o'clock agrees with the interpole corresponding to 1 o'clock, the connection is correct. If it does not, the connection must be reversed and to reverse this connection means reversing the interpole connection. The interpole connection is usually made permanent in the factory and is inside the motor. To make the change usually requires unsoldering this connection and making a new connection with the proper change.

"In order to simplify the relationship of interpoles to the main poles, I present here a diagram from my notes which is well worth the trouble of preserving. Acknowledgment is made to the author, D. H. Braymer, for the use of this diagram, which appears in his book 'Armature Winding and Motor Repair.'

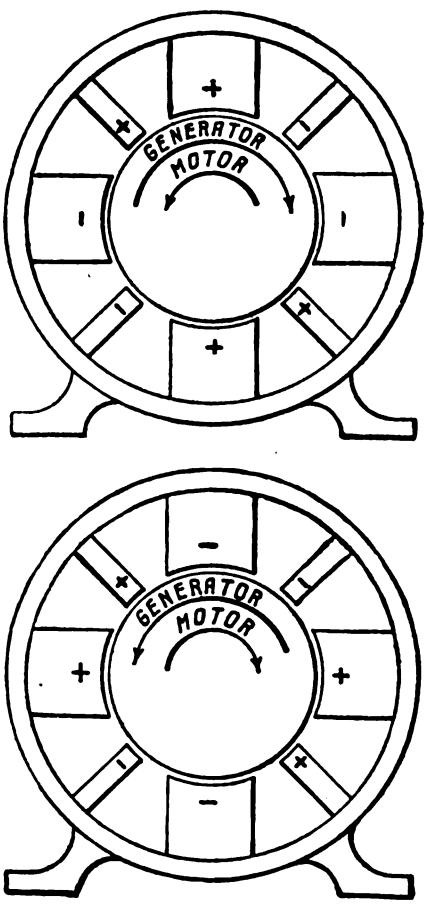
"The foregoing has been a hasty review of difficulties that may arise from what may be termed 'mechanical troubles.' It has been my practice to look for mechanical troubles first, for most of us are prone to consider all troubles with electrical apparatus as purely electrical and we make a big noise trying to make a mountain out of a molehill. Anyway, it is an idea well worth trying."

"Now that you have proved your point about these mechanical troubles, tell me, Ed, about some of those sneaking electrical troubles that act like fleas; that is, just when you think you've caught them, they've hopped to another place."

Ed got this point and came back with the following experience:

"I recall such an instance involving a constant-current transformer which gave us much concern when I was in a power house. This transformer was made by a well-known manufacturer and rated at 25 kw. It was connected to a street lighting circuit of 12 kw. and used to get so hot that its operation was hazardous from our point of view and we shut it down. This happened a couple of times and we finally tore it down to see whether or not any packing was left in the case or the operating mechanism damaged in any way, but such was not the case. As this was one of the plants under my jurisdiction I requested one more trial, but got no better results and the matter was called to the knowledge of my superiors.

"With the operating engineer and the maintenance chief directing a test, we found the output to be slightly over 12 kw. and the input nearly 21 kw., the loss being 8.64 kw. There was no plausible explanation of this. Accordingly a service man was called and he said the transformer was OK after he had given it a complete test. He also ascribed its action to aging of the iron with the explanation that this was the usual case under existing conditions. Somehow or other I was still skeptical of this proposition, but we put it in service and left it in service. It finally got tired of getting all 'het up' about having to work every night and as far as I know gave us no further trouble.



Polarity of interpoles with relation to main poles for direction of rotation as motor and generator.

"Commutators are sometimes a source of trouble and a good place to get into trouble is during repair and in the after-effects. It is of the latter that I will speak, referring to a large commutator that was repaired in the field. Commutators have an 'aging' process of their own which is completed before they leave the factory and if it is at all practicable they should be repaired in the factory.

"This particular commutator was repaired and immediately put in service because the customer needed his machine badly. He was told that the commutator would require further treatment before it would be in good condition, for it was a 'green' commutator. So far so good, but it was only a matter of time until the customer wrote a very uncomplimentary letter to the manufacturer about his products and his service men, due to the fact that he had not taken care of his machine during the seasoning process. After this machine had been in service long enough to heat the commutator thoroughly, it should have been shut down periodically and the commutator checked, nuts tightened, etc., with special attention given to the mica insulation. This would have given him a good commutator with no further repairs and no reason to berate the manufacturer and his service men.

"Heating of the commutator for seasoning is accomplished in various ways, such as wrapping it with asbestos and using a heating element, actual service, and by using wooden brushes. Circumstances make one or the other of these methods applicable to a particular case, but I have found that where it is possible to economically operate a machine without load, that the last method is the best. It consists of making brushes of hard wood the same size as the regular brush, placing them in the brush holder under high tension and running the machine. This method has the advantage of seasoning a commutator under conditions of actual operation, especially as regards centrifugal force. It also presents an exaggerated idea of brush loss.

"While on the subject of commutators I might say that the grinding in of brushes on a large commutator

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What Happens During

Single-Phase Operation of Polyphase Motors

Together with Experimental Data Showing the Changes That Take Place and How Motors May Be Protected from Damage Due to Such Causes

By R. G. WARNER
and W. B. HALL
Electrical Engineering Department, Yale University

WHAT HAPPENS when a fuse blows in one wire of a three-wire line feeding a three-phase induction motor? When one wire is interrupted, by a blown fuse or otherwise, the motor will continue to run, single phase. This occurrence is the cause of a large proportion of industrial motor failures, or "burn outs," and the answer to the above question is of great importance to every plant engineer. In this article Mr. Hall and Mr. Warner tell just what changes take place in the load placed on the windings of both star- and delta-connected motors and also give methods of protecting motors against damage from such causes.

WHEN one wire of a polyphase circuit is interrupted, by the blowing of a fuse or otherwise, the motor will continue to operate. The speed will drop perhaps one or two per cent, depending on how heavily the motor is loaded. This is a barely perceptible amount. The slight change in humming is not distinguishable through the other noises in an industrial plant; so the operator keeps on using the motor, and does not know that any change has taken place.

Although the motor will continue to run single phase, if it is already running when the circuit is broken, it will not start single phase. When an attempt is made to start the motor after it has been shut down, it will hum but will not start. The operator then knows that something is wrong and the trouble will be found and remedied. However, with many present-day, "across-the-line" starters, the starting position of the handle short circuits the fuses that protect the motor, in order that the starting-rush may not blow them. If one of *these* fuses has blown, it will be shorted out during starting, and the motor will start normally on all three phases. When the handle is thrown to "run" the fuses are placed in circuit, and the motor runs single phase. With a starter of this type, the motor might be used indefinitely with one fuse blown, and the operator be unconscious of the fact.

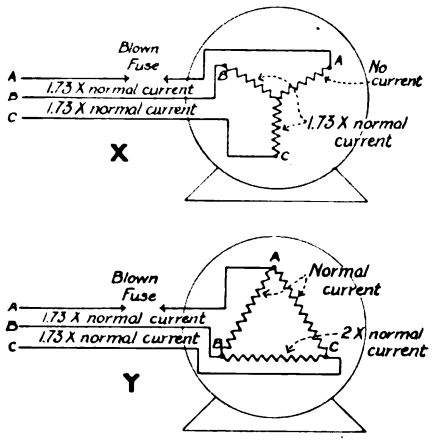
Assume that a three-phase motor is carrying its full rated load. Then, during three-phase operation it will draw its rated current. Running single phase, it will be carrying the same load. Therefore, it must draw the same total power. This will require a current that is slightly more than 1.73 times as large as before. This may be sufficient to blow the remaining fuses. If it does, the situation is cared for. But quite often the fuses are heavy enough to permit of momentary overloads on the motor, which is quite allowable, and this current will not blow them. Then what happens in the motor? This depends on whether the motor is connected star or delta.

If the motor is star connected, as is shown in diagram *X*, the windings of one phase will be carrying no current, and the windings of the other two phases will be carrying 1.73 times normal current. If this continues, eventually these windings will overheat and burn out.

If the load is less than full load, all these currents will be cut down proportionally. If the load is 58 per cent of normal full load, the star-connected motor will have normal line current and normal winding current, and be able to operate indefinitely without overheating.

These diagrams show the amount of overload placed on windings of three-phase motors that are operating single phase.

In the star-connected motor shown in diagram *X*, no current flows through the line wire *A*; hence phase winding *A* carries no current. Phase windings *B* and *C*, however, carry 1.73 times normal load. In diagram *Y*, a delta-connected motor operating under the same conditions will have normal current in the phase windings *AB* and *AC*, but twice normal current in the phase winding *BC*. These facts are also shown in the data given in the accompanying table.



If we had fuses or other protective devices in the line which would just carry normal current, and would blow if that value were exceeded, the star-connected motor would be safe against damage due to single-phase operation.

If the motor is delta connected, as is shown in diagram *Y*, the line current will be the same as in the previous case; that is, there will be no current in the interrupted line and 1.73 times normal current in the other two lines. But this current will divide between two internal paths in inverse ratio to their impedances, so that one-third of this current will pass through two windings, and two-thirds will pass through the third winding, that is, ⅓ of 1.73=0.58 or 58 per cent of normal current will pass through two of the phase windings while ⅔ of 1.73=1.16 or 116 per cent of normal current will pass through the third phase winding.

Normal current for these windings is 58 per cent of the normal line current; therefore, the two lightly-loaded windings will be carrying their normal, full-load current, but the winding across the active phase will be carrying twice its normal current. This is a worse condition than in the star-connected motor; so the delta-connected motor will be even more likely to burn out.

In the delta-connected motor, if the load is 58 per cent of normal full load, the line current will be normal, but the current in the active phase winding is 1.16 times normal

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Test Data Showing Effect of Single-Phase Operation on a Three-Phase Motor

Line Voltage			Line Current			Phase Current			Speed R.P.M.	Average Line			Induct'n Motor	Torque
AB	BC	CA	A	B	C	AB	BC	CA		I	Watts	P. F.	Output Watts	lb.-ft.
219.5	219.5	219.5	39.7	38.8	40.6	22.5	22.4	23.3	1,746	39.7	13,500	89.5	11,920	48.1
189.0	220.0	208.0	0	36.5	36.5	25.4	48.0	25.2	1,738	73.0	14,700	91.6	11,870	48.1
203.0	219.5	208.0	0	39.9	39.9	14.0	26.0	14.2	1,763	39.9	6,650	76.0	5,403	21.6
198.0	219.5	208.0	0	49.7	49.7	17.3	32.6	17.6	1,755	49.7	9,200	84.3	7,669	30.7
206.0	220.0	208.0	0	34.7	34.7	12.0	22.7	12.7	1,768	24.7	4,950	64.8	4,019	16.0

winding current. The corresponding heating is 1.33 times normal in the active phase. Hence fuses which just carry normal current and no more do not fully protect the delta-connected motor against overload due to single-phase operation. We may have a 16 per cent overload in one phase with only normal current over the line.

These facts are borne out experimentally by the data given in the accompanying table. These data were taken on a delta-connected motor, which had special leads brought out from the windings so that current readings could be taken in the phase windings as well as in the lines supplying the motor. The first line of the table gives the relation existing between the line voltages, line currents, and phase currents, when the motor is under normal operation. As will be noticed the three line voltages, *AB*, *BC* and *CA* (these letters are same as in diagram *Y*) are equal and the currents in the three lines are approximately equal. This is also true of the phase currents; that is, the currents in the phase windings (legs of the delta) are approximately equal. In the next four lines of the table the relations are shown that exist when the current through the *A* line wire is interrupted. As can be seen the motor maintains the voltages between the lines *A* and *B* (*AB* in table). The motor load in watts and in lb-ft. torque is given in the last two columns of the table.

In line 2 of the table the motor is carrying full load torque. The line current is a little more than 1.73 times normal. The currents in windings *AB* and *CA* are nearly normal. But the current in *BC* is twice normal.

In line 3 of the table the torque is reduced until the motor is drawing full load line current. This load would not operate any fuses or overload relays rated at full-load motor line current. Yet the current in winding *BC* is more than 16 per cent above normal.

Line 4 of the table shows an intermediate load between lines 2 and 3. Line 5 shows the load which gives normal current in winding *BC*. This is the maximum load with which the motor can operate single phase without carrying an overload. But notice that this draws less than normal line current.

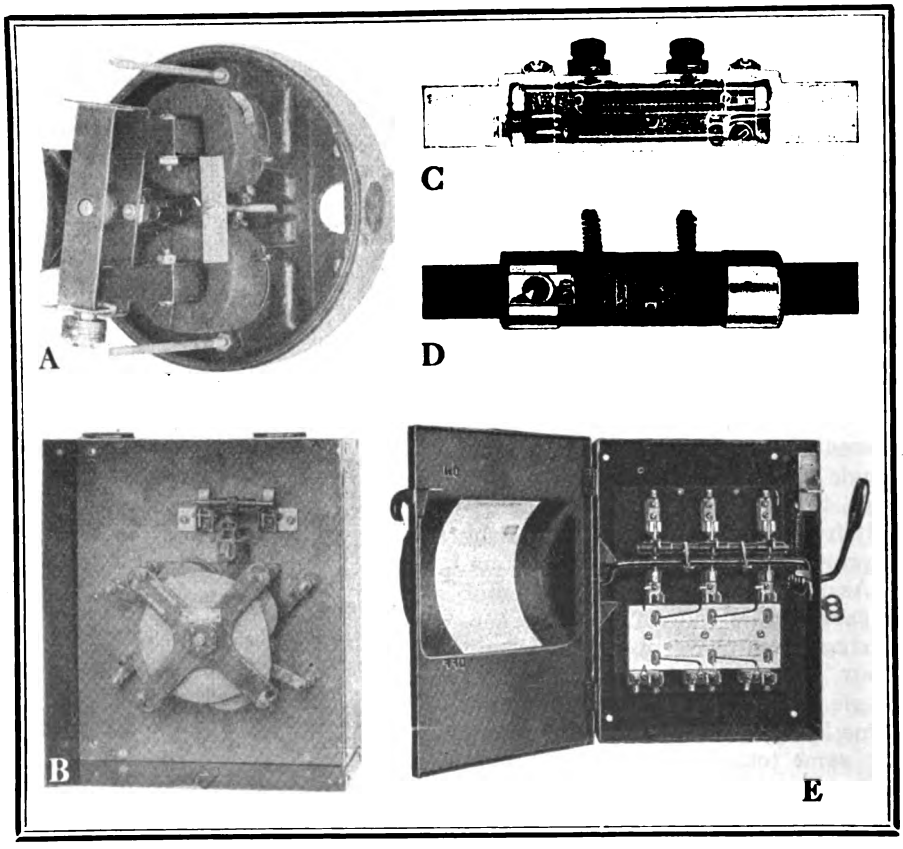
For a two-phase induction motor operating single phase the current in the active phase is double the value with the same load under normal two-phase operation. Overload protection should protect this motor from damage.

How can we protect a motor against damage due to single-phase operation?

(1) Do not over-fuse. However, our fuses must be heavy enough to take care of momentary overloads. If we could set our fuses to blow with *any* excess over full-load current, a star-connected motor would be fully protected. A delta-connected motor would still have 16 per cent excess current in one winding. But

These devices were especially designed to protect against single phase operation of polyphase motors regardless of the amount of load carried.

There are some applications where it is necessary to protect against single phasing for reasons other than overload. For instance, in some machines, weaving certain kinds of cloth, it has been found that the difference in speed between three phase and single phase is sufficient to cause a difference in the texture of the material. The devices shown below are intended to shut down the motors whenever single phasing occurs, no matter what load is on the motor. At *A* is shown a phase-failure and phase-reverse relay made by the Cutler-Hammer Mfg. Company of Milwaukee, Wis. This relay is intended to give protection to equipment in case of phase-failure while running, of phase-reversal, or in case of a dead phase when starting. At *B* is shown the open-phase and phase-reversal relay made by the General Electric Company. It is said that this relay will not trip on balanced overloads but will trip on unbalanced overloads, such as caused by single phasing, or on phase reversal. At *C* is shown a multiphase, time-limit renewable fuse made by the Federal Electric Company of Chicago, Ill. This has a powder-packed, time-limit, renewable fuse in which is placed a small heat coil, the terminals of which are on the side of the fuse. These auxiliary terminals are connected to the line and load ends of an adjacent fuse. In case the adjacent fuse is blown, the open-phase voltage across the blown fuse is impressed on the heat elements of the first fuse. The heat element melts the fuse and then melts itself, thus making two breaks in the circuit and shutting down the motor. Likewise, the remaining fuse is blown if the motor is three phase. The extra connections required by this fuse may be made by external wiring, or by the use of a special fuse block as is shown in the safety switch at *E*. In this case, a back-connected, auxiliary contact fuse is used, as shown at *D*.



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we do not usually fuse as closely and accurately as this.

(2) Use protective devices that open all three lines together. Most compensators have overload trips that do this. Many across-the-line starters for small motors do not, but some give such protection.

If we have thermal relays for protection, it is possible to set them for exactly full load, for they provide plenty of time interval for permissible overloads.

These really protect a star-connected motor from damage due to single-phase operation, and permit only the 16 per cent excess current in a delta-connected motor. This amount of current is not sufficient to damage the motor provided the motor were not exposed to excessive external heat. But they must be properly installed and adjusted.

(3) There are relays on the market designed specifically to protect a motor from single-phase operation. These are additional devices and do not protect against overload.

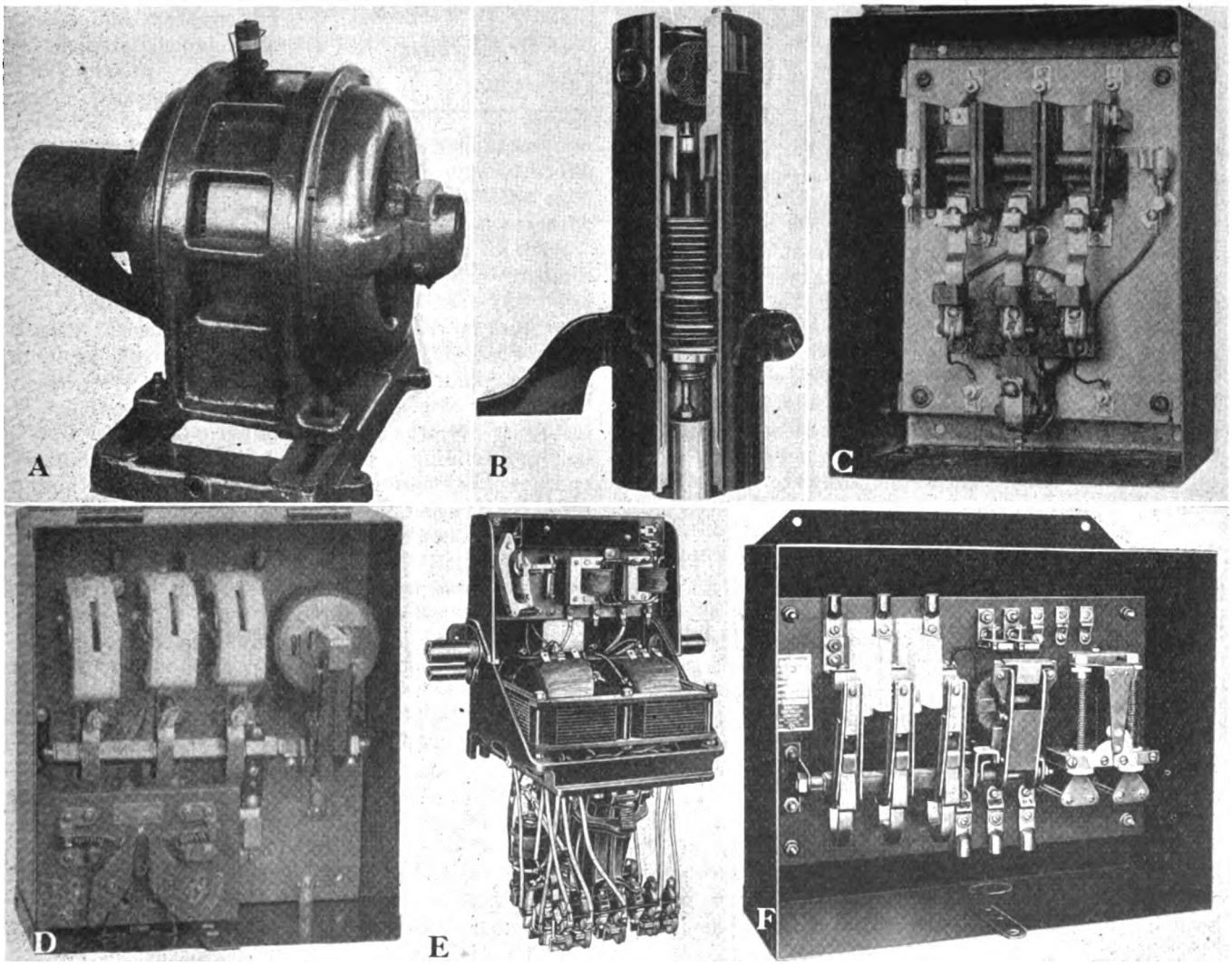
(4) There is also a simple fuse combination on the market that is so arranged that in case one fuse of a set of three fuses blows, another one of the three will immediately blow, thus shutting down the motor. This device thus protects against both overload and single-phase operation.

(5) There is also a thermal relay which can be attached to the motor and in contact with the stator laminations. This relay is said to function directly from the heat of the motor and therefore is claimed to protect the motor from overloads by single phasing or otherwise.

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Thermal relays depend upon the heat developed by the motor line current for operating their tripping mechanism.

In consequence, a time delay in tripping is obtained which is based upon the amount of overload current doing the heating and upon the time required for the thermal elements to be heated by this current. At *A*, the Type TR thermal relay made by the Automatic Reclosing Circuit Breaker Co., of Columbus, Ohio, is shown mounted on the frame of a motor. At the bottom of the sectional view of the relay shown in *B* is a liquid-filled bulb, which rests against the stator laminations. Excessive heat from the stator laminations volatilizes the liquid, which causes the copper bellows above the bulb to rise and operate the switch at the top of the relay. This device is said to protect against both overloading and single phasing inasmuch as it functions directly from the heat developed in the motor. *C* is an across-the-line starter, made by The Rowan Controller Co., of Baltimore, Md. Inside of the flashguards and directly over the blowout coils is a bimetallic strip which is acted upon by the heat developed by the motor line current in the blowout coils. Overloading of the motor causes this thermal relay to open the starter, thus stopping the motor. In the lower left-hand corner of *D* is shown the thermal relay used by the General Electric Co., in its across-the-line starter. Two heating elements connected in separate phases transmit to two thermostatic strips a heating effect that is in proportion to the load current passing through the heating elements. Load currents above normal cause the thermostatic strips to deflect and trip the motor off the line. *E* is a compensator made by the Electric Controller & Mfg. Co., of Cleveland, Ohio. An expansion wire located at the top of the compensator is used to provide overload and single-phase protection. This wire expands under the heat developed in it by the load current. *F* is the Thermaload starter made by the Monitor Controller Co., of Baltimore, Md. At the extreme right is shown the thermal relay which is used for protection against single phasing and overloads. Line current from two phases is carried through two thermal elements. Each of these elements is enclosed in an expansion tube which absorbs the heat generated in its unit. Line current greater than normal generates sufficient heat to cause the expansion tube to expand until a control contact is broken, thus stopping the motor.



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INDUSTRIAL ENGINEER
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Editorial Director

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Chicago, April, 1925

Plans Are Not Finished Until Results Are Known

IN PLANNING changes or alterations in production conditions, it frequently happens that the proposed change is not investigated thoroughly from the standpoint of all of the effects which may be produced if the change is adopted. One of the points which is frequently neglected is carrying through a full and complete investigation of the equipment which would be available for the service proposed. A striking example of this was in the construction of a building in which it had been planned to use a number of industrial electric trucks and tractors. The building plan, as originally laid out, was such that this equipment could have operated satisfactorily. However, during the period of construction, it was decided to change the plan somewhat and build a long ramp at a steep grade. Later, when manufacturers of trucks were called upon for an estimate, it was found that the grade of the ramp was steeper than trucks can ordinarily operate on. At that late time, it was impossible to change the building construction, so it was necessary to persuade a manufacturer to make alterations in his design to take care of this extra duty. Usually such makeshifts are not only not satisfactory, but they do not operate at the high efficiency under which standard, carefully-designed equipment can operate.

Full Voltage Starting of Larger Motors

THERE seems to be no question that all induction motor windings can be satisfactorily braced to stand the mechanical effect of full voltage starting, is the conclusion reached by J. L. Rylander in a paper read before the mid-winter convention of the American Institute of Electrical Engineers.

At the present time across-the-line starting is quite common on motors up to 15 hp. Extension of this method of starting to the larger sizes of motors means more to the industrial user, however, than merely securing motors with better coil bracings. The industrial motor operator must consider the strength of the machine driven by the motor, the character of the starting cycle required by this machine, whether the high-inertia starting load of the machine will result in belts slipping during starting thereby burning the belting, whether backlash in the gearing is going to result in broken gears, and whether excessive stresses will be put on other mechanical forms of power transmission between the motors and the machines driven by them.

He must also consider the effect of larger starting current on the feeders and whether or not this larger current is going to affect seriously the voltage regulation of these feeders. If he is a user of central station power he must consider the attitude of the central station toward drawing momentary heavy starting currents from their lines.

Full-voltage starting of squirrel-cage induction motors will greatly simplify the control equipment required and the attendance needed during starting of motors at the beginning of a run, or after a power failure. However, before putting in this type of control and the motor required with it on the larger drive units in the plant, careful consideration should be given to *all* of the factors involved, to make sure that the application is correct from both operating and maintenance standpoints.

Spare Part Stocks as Breakdown Insurance

EVERY now and then we hear an executive in an industrial plant say something to the effect that his inventory of spare parts required for repair and maintenance work is too high, and that he can't afford to pay interest on such a lot of capital for supplies that lie idle until emergency causes them to be withdrawn from the storerooms.

Such an argument is very similar to the one that a company can afford to carry its own fire insurance risks. If the building construction is absolutely fireproof and no combustible material is housed in it, that may be so, but this is far from the conditions in the average manufacturing establishment and one good fire can quickly wipe out enough investment to cover fire insurance premiums for a long period of time. Just so it is in providing spare parts for natural wear and tear and possible emergencies that will stop production and disarrange department schedules. Here we have a practical example of that familiar jingle, "For the want of a nail the shoe was lost; for the want of a shoe the horse was lost; for the want of a horse the general was lost; and for the want of a general, the battle was lost—all for the want of a horseshoe nail."

Suppose $50,000 is invested in spare repair parts and that the interest and carrying charges run as high as 15 per cent. This will represent $7,500 a year as the cost of repair insurance. Unless the plant is in a large city close to adequate stocks of materials, who can say that two serious breakdowns might not cost several times this figure in a single year if the needed repair parts were not available? Then, too, when these stocks are available and repairs are made while they are small, so that there are no serious and expensive breakdowns, in how many cases is credit given to the foresight and

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good judgment of those in charge of repairs and maintenance for the wise and intelligent use of this investment, which on the books of the company appears to be a useless investment that might very well be done away with?

An accurate answer to this question will in most instances show a total ignorance of the possible savings that an experienced maintenance man can work out, and indicate that in too many cases his salary is based upon the number of hours he works and not on the actual earnings that he can show when $50,000 worth of spare parts and units are at his command to use when and where needed in a medium-sized works. The problem in inventory of these spare parts is not the total money they represent, but how effectively they are used in a definite program of continuous repair and maintenance work to keep up with natural wear and tear and forestall possible breakdowns. Adequate spare parts are just as essential as adequate stocks of raw materials, because the consumption of raw materials in and through machines has a definite bearing on the consumption of repair parts. No human being has yet found the way to eliminate natural wear and tear on rotating or reciprocating parts under constant or excessive loads, be these parts in mechanical or electrical machinery.

Give the Code a Chance to Answer Your Questions

IN VIEW of the questions relating to the installation of electrical equipment which are sometimes asked by practical men, there is reason for wondering if these men are as familiar as they should be with the requirements of the National Electrical Code. Anyone who has to do with the installation of wiring or equipment and does not make constant use of this little book is overlooking a very good source of information.

It should hardly be necessary to say that the Code, as it is familiarly called, is the boiled-down essence of safe practice. The regulations which it sets forth are the results of many years of experience with electrical installations of every character, viewed from every angle. As a reference work, it contains the answer to practically any question that may come up in the installation of any kind of power equipment that is driven by, or makes other use of, electrical energy.

In these statements there is no intention to imply that the Code is a perfect and finished work. The fact that it is revised from time to time, to meet new conditions or needs, shows that it is, however, a live document—not a set of obsolete regulations, perhaps good in theory but unworkable in practice. You may not see the reason for some of the requirements, and you may not agree with them. Regardless of the merits of this situation, you can not go wrong in obeying them. Otherwise, there is always the very good chance that mistakes which are costly in both time and money, will be made.

If you do not have a copy of the Code, get one and become thoroughly familiar with the subjects covered. Therein you will find the answers to many a puzzling question as to what is the required practice and safe procedure under given conditions.

Should the Entire Motor or Only a Part Be Changed?

ARE we justified in changing complete motors rather than armatures or field coils, as the case may be, when motors fail in steel mill service, was the question discussed by A. C. Cummings, Superintendent of Electrical Department, Carnegie Steel Company, Duquesne, Pa., before a recent meeting of the Association of Iron & Steel Electrical Engineers. He directed attention to the following points in favor of this practice:

(1) The repair shop personnel is usually a higher-paid and more intelligent class of men than those occupying mill maintenance positions. They, therefore, have more interest in making a thorough job of repairs than the mill men.

(2) Repairs made in the field, with a piece of apparatus shut down, are always made under rush conditions, and the care necessary to make a thoroughly workman-like job in every particular cannot be exercised when the men are being rushed to get the equipment going as soon as possible.

(3) Armatures and field coils stored around the mill to be installed in the motors in case of failure, usually are damaged in handling before they are actually installed for service, and for this reason do not perform as well as anticipated. If the complete motor is repaired and assembled in the shop and sent out on the job as a unit, there is little likelihood of damage due to careless handling.

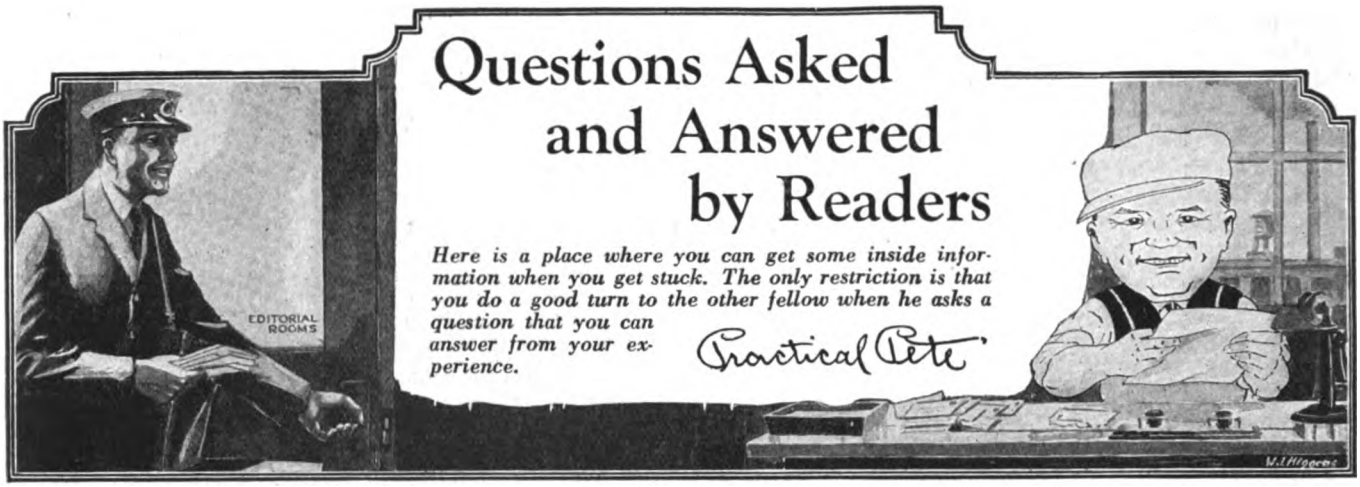
It was pointed out that in most cases a complete motor can be substituted without an increase in the time lost in making the change, or in the amount of money invested in spare parts. Even if there were an increase in the amount of money so invested, it would be more than offset by the decrease in delays and maintenance cost. On the other hand, if this practice is to be followed, it is very important that facilities be provided to do this work with as much convenience and dispatch as possible. During the past several years there has been a tendency toward increasing size and capacity of mill machinery and mill parts, with a corresponding tendency toward an increase in the size of motor equipment used. The average motor size, therefore, is gradually increasing. This is particularly true of motors used on overhead travelling cranes.

While the discussion of this question is based on a background of steel mill experience, still the practice is worthy of consideration in any industry where it is necessary to keep power service interruptions to a minimum.

In the last analysis the question must be decided on the local conditions in your own plant. Factors that should be considered are: Number of types and sizes of motors in the plant (in the older plants, providing complete spare motors for the very old motors may be a serious factor); additional facilities that might be required for changing the larger motors with dispatch; possible decreased cost of shop repairs as compared to field repairs, together with the probability of longer life; the possibility of using less skilled men for changing complete motors than is required for changing parts of a motor; and the satisfaction of knowing that when a complete motor is substituted it will be in first-class condition, as compared to the chance that only a part of the motor will be in first-class condition when only a part of it has been changed.

This bet should not be overlooked, if reduction of your motor maintenance cost is one of your worries.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Cost of Changing Two-Phase Motors to Three-phase—The local power company is planning on changing its system from two phase to three phase. This will involve a corresponding change in a large number of motors ranging from 5 hp. to 50 hp. I should like to know if there will be any loss of efficiency in the motors as the result of this change. Also, please tell me the general procedure involved in changing motors from two phase to three phase, what troubles are likely to be encountered and about what the cost per motor or per horsepower will be.
Fort Smith, Ark. V. L. H.

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Connecting Commutator Leads of G. E. 25-Cycle Desk Fan Armatures—Will some reader please tell me the general layout of the coils and how the top and bottom leads are connected to the commutators of G. E., Type AOU, Form V2, 25-cycle desk fan armatures? I have rewound two different armatures without much success, for when the fan is connected across the line the armature rotates only very slowly, with the fan removed.
Phoenix, Ariz. F. R. S.

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Connecting Lineshaft Directly to Motor—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.
St. Louis, Mo. B. G. S.

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How Can This Motor Be Kept From Humming?—Can someone tell me how I can eliminate the magnetic hum of a 30-hp., shunt-wound, four-pole, 400-1,000-r.p.m. interpole motor? This hum is so loud that it can be heard all over a large department store. The following remedies have been tried: (1) Laminated pole shoes supplied with motor were changed for similar shoes of sturdier construction. The laminations in the new shoes were put together under pressure, riveted with bakelite varnish between them and baked. This did not stop the noise. (2) The air gap was increased. This helped somewhat, but caused circuit breaker to open. (3) Cast pole shoes were used, with no noticeable effect. (4) Skewed laminated pole shoes were tried, with no better results. (5) Used pole pieces with wider air gaps on tips. No results. (6) Magnetic wedges were used in armature slots. These helped somewhat. (7) Disconnecting interpoles had no effect. Before the magnetic wedges were tried, if full field strength was applied and the armature turned slowly by hand, with the brushes lifted up, it had a tendency to lock at several points. If rotated faster it would growl. Magnetic wedges almost removed this effect. Two wedges per slot were used, each 1/16 in. thick and insulated from each other. All armature connections are OK.
New York, N. Y. W. L. S.

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Rewinding Armature Increased Speed—I recently rewound the armature of a 100-hp., four-pole, shunt-wound, Northern motor and wish someone would tell me what is the matter with it. This armature had 110 bars and 55 slots and was wave-wound, with one dead coil and one half-idle bar. The coil pitch was 1-and-13 and the commutator pitch 1-and-56. When we rewound it one bar was taken out, which left 109 bars and one dead coil. I am not sure whether the commutator pitch was 1-and-56 or 1-and-55. When the armature was put back in the motor it ran at about 1,600 r.p.m., the commutator got hot and the bands threw solder, although the controller was on only the third point. I examined the field connections and took the voltage drop across each field coil; everything tested out OK. As a further check, a spare armature was put in this motor, and ran perfectly. Any suggestions you can give will be very welcome.
Wisconsin Rapids, Wis. W. B. L.

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When Should an Armature Be Scrapped Instead of Repaired?—I shall appreciate it if readers will give me their opinion on the following: If an armature needs new coils, a new commutator and a new shaft, especially if it is of the type that has the laminations stacked on the shaft, is a repair job, with only the laminations for a base, a profitable undertaking? Also, when should the core be junked and new laminations used?
Chicago, Ill. J. E. K.

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Replacing Motors When Trouble Develops—When armature or other troubles develop in a motor, should a new armature be put in or other repairs made, right on the job? Or is it better to replace the entire motor with a spare and send the damaged motor to the repair shop? This question has come up several times in our plant and I should like to know the practice followed by other readers.
Pittsburgh, Pa. E. W. D.

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Method of Restacking Transformer Core Laminations—When we restack transformer core laminations we often experience trouble in getting all of the iron back in place so that the cores will fit in the cases. We have followed the practice of burning paper underneath the cores after the laminations have been stacked. I should like to know (1) if this is good practice. (2) Is there any danger of removing the insulating varnish from between the laminations, thereby causing the cores to heat?
Chicago, Ill. G. C. C.

Answers Received To Questions Asked

Reclaiming Leather Belting—I should like to know if any readers have made an investigation to determine how much belting must be in use before it will pay a plant to undertake belt reclamation work. I should also like to know the amount and kind of equipment required to do such work and about what savings we could expect to make. I shall appreciate any suggestions or information you can give me.
Cleveland, Ohio. E. E. L.

Replying to E. E. L.'s question in the February issue on reclaiming leather belting, we would say that if we understand your question what you want to know is how large a plant you must have or how much belting in use before it pays to set up an equipment for reclaiming, that is, degreasing, lapping, re-gluing, etc. The answer to this will pretty obviously depend upon the nature of the drives; in other words, upon how quickly belts are deteriorated due to the nature of service to which they are subjected.

Where there is a great deal of oil or dirt around, it probably would pay to reclaim belts in a plant where there was less belting in use than in a larger and cleaner plant where the conditions were more ideal. A gasoline tank of sufficient size to hold the belts in loose rolls would be required, with proper safeguards for fire hazard, and preferably the work should be done out of doors or in a shed distant from other buildings of importance. There should be a dry, airy shed out of the buildings where the belts can be allowed to dry, that is, the gasoline to evaporate, and, of course, the size of this will depend entirely upon the amount of work done. In the summer time it can ordinarily be done outdoors; possibly in a garage or some such place which is open and not closed up tightly.

After the leather is degreased, it will have to be re-lapped. A good set of belt tools, including a small lapping machine, such as the Prims Machine made by J. C. Prims, Hornell, N. Y., should be installed. A man who understands the cutting of laps, gluing, cement, etc., will be required, and then a small treating tank, in which the belts could be treated in a proper belt preserver.

Where belts receive a good deal of abuse, an appreciable saving probably could be made, and in large plants it

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would be quite a large item. It all hinges upon whether there is enough work to justify the time of a man, as the investment in equipment is only small.

Of course, a small press would be required but a hand press would ordinarily be sufficient. Probably in most small plants, it would be cheaper to send such belts to a belt manufacturer and let him do it.

J. EDGAR RHOADS.

J. E. Rhoads & Sons,
Philadelphia, Pa.

* * * *

How to Determine Amount of Plugging Resistance to Use—I would like to know the right way to figure the amount of resistance used for starting series motors that are plugged, such as on blooming-mill, roll-table motors, crane-trolley motors, or any motor that is subjected to plugging service. I would also like to know how to figure the resistance used in the secondary circuit of slip-ring motors driving fans. Mingo Junction, Ohio. E. E. S.

Replying to the question by E. E. S. in the January issue, if a motor does not start from rest, but is plugged, the maximum voltage across the armature and its accelerating resistor is the sum of the line voltage and the counter-voltage developed by the motor at the instant of reversal. In order to limit the current with these combined voltages a plugging resistor is required. The proper value of this resistor can be determined by dividing the counter voltage of the motor at the instant of reversal by the allowable current in-rush. This value can be discounted by 10 or 15 per cent to allow for resistance and reactance of leads and loss of speed at the instant of plugging. This resistance should usually be added as a single step.

In order to calculate the balanced three-phase secondary resistance necessary for a wound-rotor induction motor, the locked rotor volts, and the full-load secondary current must be known. When the locked rotor voltage is known the full-load secondary current can be found by the formula: Full-load secondary current equals hp. times 746 divided by the locked secondary volts times 1.73 times (1 minus the slip).

The Y-connected, balanced three-phase secondary resistance can be found by the following formula: Resistance per leg of the Y, in ohms, equals the locked secondary volts divided by 1.73 times the full-load secondary current times (100 divided by the torque developed on the first point of controller or contactor, expressed in per cent of full-load torque minus 0.10).

The secondary resistance for wound-rotor motors is usually connected in Y. There are cases where it is desired to reduce the current handled by the controller fingers; in such cases the resistor is connected delta. If the resistors are delta-connected, determine the proper value of Y-connected resistance and multiply by three to get the proper resistance of each leg of the delta. The current in each leg of the delta-connected resistors is the motor secondary current divided by 1.73.

MARTIN G. LANE.

Asst. Chief Electrician,
Superior Mines, Union Pacific Coal Co.,
Superior, Wyo.

Throwing Large Squirrel-Cage Motors Across the Line—Will someone who has had experience with starting large squirrel-cage motors (50 hp. and larger) by throwing them directly across the line, please report their results? Has such practice injured the motors in any way? Has it resulted in any damage to the machinery driven? Has it interfered with the supply of current to other motors in the same plant? Indianapolis, Ind. D. W. T.

In answer to D. W. T.'s question in the January issue, I should like to say that this is common practice in the coal industry where a. c. mining machines are used. These machines usually run from 35 to 50 hp. The stators on these machines are connected through controllers arranged for star or delta connections.

This system is very successful and does not cause any damage to the machines nor does it have any bad effects on the voltage or other motors, outside of a slight surge.

We have also on several occasions had to start a 200-kw. motor-generator set by throwing it across the line.

This is very risky both to machine and operator and I would not advise doing it except in extreme emergencies, and then the oil switch would have to be thrown in and out very rapidly until the machine is brought up to half-speed, when it can be left in without danger. H. BANHOLZER.

Electrical and Mechanical Engineer,
Knox Consolidated Coal Co.,
Bicknell, Ind.

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In reply to D. W. T. in the January issue, throwing large squirrel-cage motors across the line is becoming regular practice, particularly for motors driving power station auxiliary equipment, as it obviates freezing of contacts and allied troubles in starting compensators, due to the inherently small rupturing capacity of such equipment during the starting period.

Motor manufacturers are designing equipment for this service and no serious trouble will occur if the service or duty of the motor is understood before installation. Troubles have occurred with motors due to lack of proper reinforcement at the ends of the stator coils, but so far as the writer knows these have been limited to the motors of one manufacturer and were rectified after installation.

The question of damage to the machinery driven must be settled by the manufacturer of the driven machine. In cases where the motor is direct-connected through gearing, there may be a possibility of damage but in every case that has come under the writer's observation, the machine manufacturer was agreeable to this method of starting and no damage has as yet been reported. Coal crushing equipment, in particular, must be carefully investigated when this method of starting is under consideration.

The question of the effect of this method of starting on the current supply to other motors in the same plant cannot be answered directly. In power station practice the capacity of the motor being started is usually so small in comparison to the generating equipment that no marked fluctuations of voltage are caused. However, in one case where a 150-hp. motor was being started with a 1,250-kva. generator supplying it, the generator being partly loaded, a marked momentary fluctuation was noticeable. This, however, is an operating feature that can be avoided.

In general, the motor manufacturer should know that the motor is to be started in this manner so that no older type of equipment with insufficient end winding reinforcement will be furnished for this duty.

C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp.,
New York, N. Y.

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In reply to D. W. T. in the January issue, it is not common practice to start squirrel-cage motors of 50 hp. and larger on full voltage. Consequently, motors of this size are not as a rule designed for this sort of operation. It is true that motors may stand a certain amount of full-voltage starting, but the best procedure is to write the motor manufacturer, giving the full rating of the motor, together with the serial number. Also advise the probable number of times the motors will start on full voltage, as well as the kinds of machines the motors have to drive. With this information the motor manufacturer will be in a position to give authentic information as to whether or not his motors can be used in this way. If such method of starting is contemplated before the motor is purchased, it is always possible to have the motor coils equipped with special bracing, which will insure against any possible coil distortion due to full-voltage starting.

Probably the majority of general-purpose, squirrel-cage type motors, 110-volt, 220-volt, 440-volt or 550-volt, 50-hp. and larger, as manufactured by reputable manufacturers, will stand a certain amount of starting on full voltage without injury. Continuous operation with this method of starting is likely to cause trouble in time, unless the motor coils have first received special treatment which will enable them to resist the strains caused by the high current which exists at the time of starting. If the motors are 2,200 volts, the windings are of comparatively small cross-section, due to the small, full-load current. Such motors are more susceptible to distortion of their windings than other motors, due to the windings having less mechanical strength.

If D. W. T. tries starting his motors on full voltage, he should watch for trouble at the point where the stator coils leave the iron stacking. Any distortion of the coils or loosening of the coils at this point may cause abrasion of the insulation where the coil bends around the iron, and in time will cause a ground. This tendency of coils to loosen is not mainly due to the mechanical shock which occurs when the motor starts, but is due to high magnetic stresses due, in turn, to the high currents which exist in the stator windings at the time of starting. A squirrel-cage motor draws several times its full-load current at the instant of starting, which value gradually tapers off to full-load value as the motor comes up to speed. The mechanical shock to the motor starting

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on full voltage is not so great as might be supposed, particularly if the load has a high frictional value, such as starting a bucket conveyor or a plunger pump. Referring to Fig. 1, curve *B* is the curve of a conveyor which starts cold after the lubrication has settled down. A torque equal to *Y* is necessary to break the static friction, which falls off to a value *Q*, after the conveyor is up to speed and all the bearing surfaces are lubricated and warmed up. The characteristic torque curve of a squirrel-cage motor is given by *C*. It will be noted that the difference between *U* (torque exerted by motor at starting) is not excessive as compared with the torque demanded by the load at starting. However, the starting current corresponding to curve *C* may be five or six times the full-load current of the motor and it is the high magnetic stresses resulting from this current which may cause the distortion of the motor windings. Curve *D* shows the motor torque curve when started by a compensator. It is evident that this is insufficient for starting up the load represented by curve *B*, although it would have the advantage of taking any back-lash out of the gearing, thus saving some mechanical jar when the motor was finally thrown on full voltage.

If the motor in question is connected by belt to a machine having very high inertia, as for example, a shear having a flywheel, the starting torque exerted by the motor may be so great as to make the belt slip, causing burned spots on the belt. D. W. T. does not state definitely that his motors are general-purpose, squirrel-cage machines, but if they are high-torque motors with high-resistance rotors, the starting torque characteristics of each motor will be similar to curve *E*. The difference between the starting torque of such a motor and curve *B* is represented by the difference between *W* and *Y*, which is considerably greater than the difference between *U* and *Y*. The attendant shock on the driven machinery with such a motor is greater, but the likelihood of trouble with the motor itself is less even though the mechanical shock is much greater. This is due to the fact that the high-resistance rotor windings reduce the inrush of current with attendant magnetic stresses, which reduces the chance of any distortion of the motor windings by just that amount. In all cases of full-voltage starting, it is important that there be no great amount of back-lash in the gearing; otherwise too great a starting torque might break the teeth of the gears.

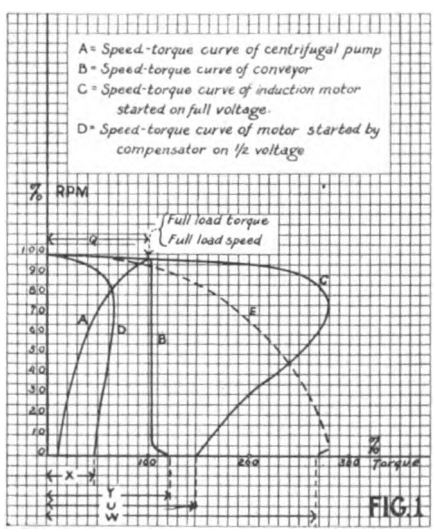
The question of the amount of current drawn from the line is often a relative one. A case came to the writer's attention recently where the operator was worried about the probable starting current drawn from the line by a 40-hp. motor started on full voltage when a 350-hp. motor which was connected to the same mains had a full-load current practically the same as the locked rotor current of the 40-hp. motor. In other words, the 40-hp. motor would have a momentary current inrush hardly any greater than the full-load current of the large motor, and considerably less than the inrush current of the large motor when starting. Some power companies specify in their rules that, "where an installation consists of a number of motors, the starting device may be omitted from any motor which, with the starting device omitted, would have a current less than the permissible maximum for the largest motor in the installation."

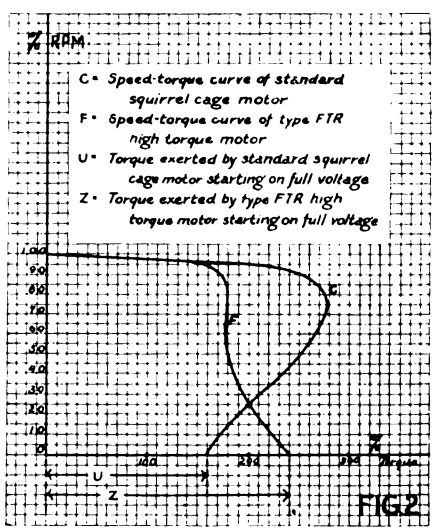
If the motor drives a fan having a speed-torque curve like *A* in Fig. 1, a compensator will give a motor characteristic curve *D*, which will permit a comparatively low starting current. However, if the load curve is similar to *B* it is doubtful if the increase in starting current due to the omission of the compensator will have any appreciable effects. For example, curve *C* shows that 150 per cent torque is exerted by the motor at full-voltage starting. The load curve *B* indicates 120 per cent torque is required. A compensator reducing the voltage to 90 per cent of full value reduces the starting torque to 81 per cent (starting torque is reduced according to the square of the applied voltage), or 121.5 per cent of full-load torque. This is barely enough to start the load and it would not be feasible to reduce the applied voltage any lower. The starting current is theoretically reduced to 81 per cent of its former value. As a matter of fact, there will probably be even a larger reduction due to losses in the compensator and unbalanced voltages. Consequently, the addition of approximately 15 per cent more current should not result in any bad effect, providing previous starting conditions were satisfactory and the power lines have a reasonable margin in capacity. Another point in favor of full-voltage starting is the fact that the increase in applied torque due to full-voltage starting means that much less time during which the higher current exists. Therefore, if D. W. T.'s load curve is similar to *B*, a compensator is of no particular advantage with a motor having the characteristics shown in *C*.

D. W. T. may also be interested to know that the current taken in starting by compensator is often much greater than any current that would ever be obtained when starting by the full-voltage method. The stator current ceases immediately when a motor is disconnected from the starting tap of a compensator preparatory to throwing the motor on full voltage. The rotor current, however, will continue to flow for a short period of time, due to the fact that the decrease in the flux tends to keep it flowing. This rotating flux generates a voltage in the stator, the frequency of which is somewhat different from the line frequency. If the compensator is thrown to the full-voltage position while this induced voltage in the stator still exists, it is possible that the induced voltage and the line voltage will be in phase opposition. This will cause a surge of current which will be several times as great as any current the motor can possibly draw from the line when started on full voltage from rest. This surge lasts for a fraction of a second, but it may have a worse effect on the motor and starting equipment than current obtained by full-voltage starting. Of course, if the compensator closes when the two voltages are in phase coincidence, there will be no undue rush of current.

The General Electric Company has a line of motors, type FTR, up to 100 hp., having high-starting torque, relatively low starting current, low slip and high efficiency, especially adapted for starting on full voltage. These are not general-purpose motors, but are designed for use with automatic refrigerating machines, automatic pumping installations, conveyors, reciprocating pumps—in fact, for all installations where high starting torque, low starting current and high all-day efficiency are desirable. Larger motors, type FT, can also be furnished with similar characteristics, except the starting torque is not as high as with the type FTR motors. Fig. 2 shows the speed-torque curve of an FTR motor compared with a standard squirrel-cage motor. Note the difference in starting torque. Also, the starting current cor-

Fig. 1—Speed-torque curves of certain types of loads and of standard squirrel-cage motors started on one-half voltage and full voltage. Fig. 2—Speed-torque curves of standard squirrel-cage motor and type FTR motor, started on full voltage.





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responding to curve *A* is considerably less than the starting current corresponding to curve *B*, in Fig. 1.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

In reply to D. W. T.'s question in the January issue, throwing large squirrel-cage motors directly on the line is not usual practice and experience on this point may be lacking; so our experience, which is similar, may be useful.

We have a lineshaft driving beaters, pumps, and stuffchest agitators, the principal load being in the beaters, which, as the stock settles and thickens, have a very heavy starting torque and slow acceleration. This lineshaft was formerly driven by a steam engine but in the process of changing to individual motor drive it was desirable to replace the engine temporarily by a motor. The only motor available was a 125-hp., 14-pole, three-phase, 60-cycle, 440-volt, squirrel-cage motor with manually-operated compensator; so it was installed. This motor will not start on less than the 90 per cent voltage tap and sometimes even refuses to start, so that the belt has to be shaken to lessen the initial friction.

But, although the motor has been operating on this service for about 18 months, pending a decision as to a rearrangement of the machinery, it shows no sign of distress or weakness. The rated motor current at full load is 161 amp., but on starting it takes from 550 to 600 amp., and although the generator is rated at 1,250 kw., there is considerable flickering of the lights. As a rule, the motor takes 30 to 45 sec. to come up to a speed where the compensator can be thrown to the running position, at which time the current has fallen to 250 amp., but jumps temporarily to 400 amp., falling back to 130 to 150 amp., which is the average running load.

We have also a 200-hp. synchronous motor that was originally purchased to drive a Jordan engine, which has starting characteristics similar to a centrifugal pump. Ultimately, however, we found it more convenient to use the motor on a large breaker beater system. This motor will not start on the 90 per cent tap without the assistance of men pulling on the belt, although this condition will shortly be corrected by a change in the amortisseur windings. However, the motor starts up in good shape when the line voltage is raised to 550 volts. At this voltage the motor takes from 700 to 800 amp. in the feeder circuit and has been started in this way several times without injury.

On the other hand, in another power house we had a 100-hp., three-phase, 60-cycle, 2,300-volt, 16-pole, squirrel-cage motor driving a condenser extraction pump. The insulation of the motor was known to be in poor shape. One day in starting up in a hurry a new watch engineer pulled the compensator handle directly into the running position—the latch was afterwards found to be stuck—and grounded about a dozen coils with a report like a cannon.

In general, if the starting torque and inertia of the motor load are not too great to allow of its accelerating rapidly and building up a suitable counter-electromotive force before the very heavy current developed by the full impressed voltage can cause undue heating, the motor will not be damaged. But as the line must be fused to stand this current, the motor has little protection unless relays are used which can be short-circuited during the starting period.

The disturbances on the power system are a more serious matter, as with a comparatively small generator the voltage may be pulled down so that undervoltage releases on other circuits operate. We have had this occur with sticking contacts on the automatic starter of the synchronous motor, and even where the fluctuation is not so great it causes a very unpleasant flickering of the lights. For this reason, most public service companies in cities will not supply service where squirrel-cage motors of over 25 hp. are installed, even with compensators, for while the starting power may not be excessive, the large wattless current affects voltage regulation.

I hope that our experience may be of some use to D. W. T.

H. D. FISHER.

Plant Engineer,
New Haven Pulp & Board Company,
New Haven, Conn.

* * * *

Replying to the inquiry by D. W. T., in the January issue, it is quite feasible to start motors of 50 hp. rating or larger, directly off the line, and it is not as a rule liable to cause much damage especially if the motor is in good condition electrically. However, it is a method which should be avoided unless everything else has been tried and the emergency is serious enough to warrant the risk.

There are several points which should be considered regarding this method of starting. In the first place, the motor should be in good mechanical and electrical condition. The load should be of small inertia or should be connected through a clutch. If the load is connected through a mechanical, magnetic or air type of clutch, so that the motor can start freely with only its own inertia to overcome, the initial rush of current will not be much over two to three times normal and will be only momentary. Under these conditions the time required for the motor to start and reach approximately synchronous speed, would be very short. With a clutch connection the type of load matters very little as long as it is the load which the motor has customarily been driving. If the load is direct-connected, however, the nature of the load should be considered. If the load is of a light nature with small inertia, it will not seriously affect the starting, but if it is a stiff, heavy load of a kind which ordinarily gives the motor a hard struggle even when starting with a compensator, it is liable to cause trouble. The danger can be reduced somewhat by putting the drive into motion before starting. I will refer to this again later.

The size of main feeders and transformers should be looked into, but if the plant has a considerable number of motors of large size, the mains and transformers, switching equipment, etc., are sure to be more than safe, and there is little chance of interrupting service on the other motors. On the other hand if the plant has only three or four motors, there would be a good chance of knocking out the main breaker. In a case like this the overload relays on the main breaker might be blocked or set up high just long enough to start the motor, and then be released.

We have started a 300-hp. squirrel-cage induction motor directly off the line, successfully. The motor in question was driving one of our most important mill lines and we had the misfortune to burn out the auto-transformer. It was impossible for us to secure a spare or to get the other one repaired inside of two weeks, and on account of production conditions we had to get it running without the loss of one moment longer than was absolutely necessary. We decided, after a survey of conditions, that it was worth while taking a chance on starting it off the line. Fortunately the motor was connected to its load through a magnetic clutch and, therefore, could be started with only its own inertia to overcome.

To start it, we blocked the overload relays on the feeder switch at the main board and at the motor switch, wound a rope several times around the shaft, started the rotor turning over by hand and with several men pulling on the rope, brought the rotor up to a fair speed; then we pulled the rope clear and closed the switch. The motor started off nicely and with no evidence of distress. We then threw in the clutch and unblocked the relays. It was necessary for us to repeat this performance once more before the auto-transformer was fixed and it worked equally well the second time.

We have had occasion to start several motors of over 50 hp. rating in this manner and by observing the precautions outlined and having the rotor turning over in the proper direction at the moment the switch is closed, we have had no injury to the motors so started, no damage to machinery, and no interruptions of service to the other motors.

By having the rotor in motion when the current is applied, the initial rush of current is greatly reduced, so that it amounts to little more than that taken by a motor started from a dead stop, with the auto-transformer on the 70 per cent taps.

Our experience along this line, although successful, led us to finally purchase a spare auto-transformer large enough to handle any of our motors, and this we have mounted on a skid, easily transported to any place required. We would suggest this as advisable if much trouble is being had with auto-transformers and starting switches. A good oil switch could also be mounted on the skid with the transformer, and such an outfit could be quickly connected and the crippled apparatus repaired at leisure.

L. J. CLAYTON.

Asst. Mechanical Engineer,
The Goodyear Tire & Rubber Company
of Canada, Ltd., Bowmanville, Ont., Can.

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Connecting Watt-hour Meter to Three-Wire Circuit—Will some reader please give me a diagram and explanation of how to connect a watt-hour meter to an Edison three-wire circuit? Is a special type of meter required? Why?
Bellaire, Ohio. J. R. B.

J. R. B. will find an answer to his question in the January issue in the accompanying diagram and explanation.

The diagram shows a three-wire meter (a meter made for the Edison three-wire system) connected to the Edison three-wire circuit. This is the connection used in conjunction with a meter loop. Note that the neutral wire does not pass through the meter, but passes through the service switch. Also the neutral is "solid"; that is, it is not fused. (See page 64, paragraph a, Article 8 of the National Electrical Code.) Since the neutral wire is grounded no fuse is needed. The neutral wire need not pass through the meter because all of the current must pass through the outside wires. This includes the unbalanced current in the neutral. Thus all the current is metered. The potential coil of the meter is connected across the outside wires.

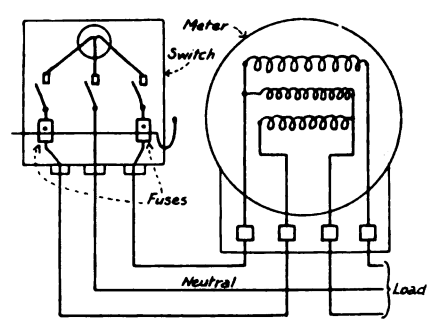
When the service switch, service fuses and meter are combined in an approved device, having no live parts or exposed wiring, and which is capable of being sealed or locked, the switch may be so connected that it will not disconnect the fuses or meter from the supply line (page 18, Article 4, paragraph b of the National Electrical Code).

The connections for watt-hour meters are the same for both a. c. and d. c. meters in the Edison three-wire system. If the supply is a. c. an a. c. meter is used; if d. c. a d. c. meter is used.

A three-wire meter as shown in the diagram is required because, as before stated, there are two wires in which the current must be metered. If the regular single-phase a. c. or two-wire d. c. meter were used current would pass to the load and back to the supply without going through the meter for the reason that there is only one current coil in the meter. Assume, for instance, a three-wire d. c. system, feeding an unbalanced load, with most of the load between the positive and neutral, and a two-wire meter whose current coil is connected in the negative side of the system. The current would pass from positive to negative through the meter and back to its source. The unbalanced current would pass from positive to neutral through the load and return on the neutral without going through the current coil of the meter, which is in the negative side. If the meter is connected with its current coil in the positive side with the unbalanced load on the opposite side, most of the load being between neutral and negative, the current will flow out through the positive, thence through the meter and load and back to its source, through the negative wire.

The unbalanced current will flow out through the neutral, through the load and return through the negative, and thus not go through the current coil of the meter, which is on the positive side. From the foregoing it is evident that such a meter could not be successfully used on three-wire circuits.

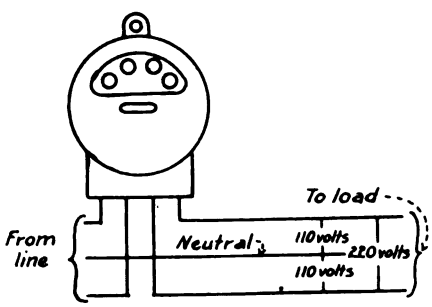
Concord, Mass. DONALD FERGUSON.



Internal and external connections of three-wire meter connected to Edison three-wire circuit.

* * * *

In answer to the question asked by J. R. B. in the January issue of INDUSTRIAL ENGINEER, as the fundamental principle of the watt-hour meter is the same as that of a motor it is no more possible to use a 110-volt motor under 220-volt pressure than it is to use a two-wire, 110-volt meter on a three-wire, 110-220-volt circuit, and for the same reasons. If you were to connect a two-wire, 110-volt meter to a three-wire, 110-220-volt circuit you would burn up and ruin the meter.



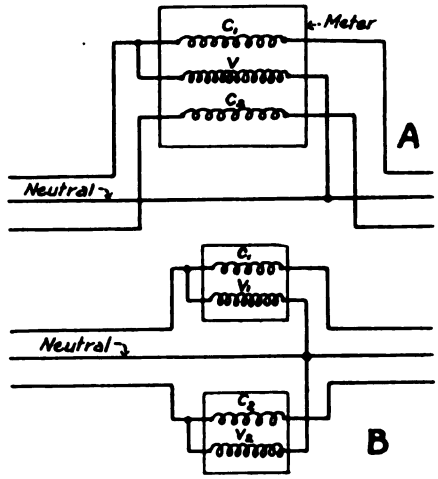
Three-wire watt-hour meter connected to Edison three-wire circuit.

The diagram shows the method of connecting the ordinary type of three-wire meter. The connection shown applies to circuits carrying from 1 to 100 amp. Current transformers must be used when the circuit exceeds 100 amp.

Inspector, Philadelphia Fire Underwriters, Ardsley, Pa. EDWIN V. LAMBERT.

* * * *

Replying to J. R. B.'s question in the January issue, in the accompanying diagram *A* shows the conventional method used by one company for measuring the energy used in a three-wire circuit. This method has the objection that if the voltage coil is connected to the line and the neutral, the voltage will be lower and the registration lower on the side carrying the greater load. When connected to the side with the lighter load, the voltage to neutral will rise and the registration will be higher than it should be. However, in the large three-wire distribution systems the unbalance is generally so small that the error in this method of connection is negligible.



Connections for measuring energy used in a three-wire circuit by means of, A, a single three-wire meter and, B, two two-wire meters.

It is also possible to obtain a meter with a voltage coil connected between the outside legs, or a coil with double the voltage of the coil shown in *A*. This gives a registration approximating the average of the two voltages to neutral and has the advantage over the other types indicated in that there need be only four terminals, as against five in diagram *A*.

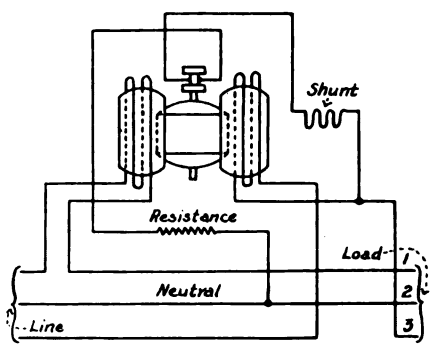
For absolutely accurate registration two, two-wire meters can be used, each connected with the current coil in the outside leg and the voltage coil to the neutral as shown in *B*. The three-wire meter is a standard type of meter and is not considered special.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp., New York, N. Y.

* * * *

In reply to the question by J. R. B. in the January issue, he may use either two, two-wire instruments or one three-wire instrument. There is very little difference in the construction of the meters and the principle of operation is exactly the same. In meters designed for use on three-wire circuits the two series coils are distinct and the ends of each are brought out to terminals The diagram will illustrate the construction and connections of a three-wire watt-hour meter for an Edison system.

The voltage coils may be connected across lines *1* and *3*, *1* and *2* or *2* and *3*.



Three-wire watt-hour meter connected to Edison three-wire circuit.

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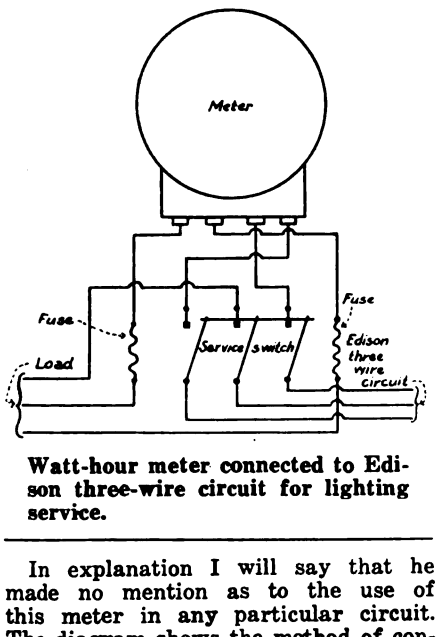
When the connection shown is used, the torque exerted on the armature is equal to the sum of the torques of coils *A* and *B*. On a well-balanced load the torques are equal and the meter will register accurately. On a badly unbalanced load, where the voltages will not be equal, the torques will not bear the same ratio to the load. On unbalanced loads the meter usually registers more power than is really used. Another important point to consider when connecting the meter to an unbalanced load is that the error is greater when the voltage coil is connected between an outside wire and the neutral.

If your circuits are subject to a serious unbalance, it would be well to use two, two-wire meters and take the sum of the readings of these two meters. This is the most accurate method in practice. Any reliable manufacturer of meters can furnish excellent meters of either kind and will be glad to give you any further information you may require. In case you are interested in meters of all kinds, Jansky's "Electrical Meters," published by McGraw-Hill Book Co., will give you any ordinary information you may wish.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Answering the question asked by J. R. B. in the January issue of INDUSTRIAL ENGINEER, the accompanying diagram of connections may be of help in solving the problem that is troubling him.



Watt-hour meter connected to Edison three-wire circuit for lighting service.

In explanation I will say that he made no mention as to the use of this meter in any particular circuit. The diagram shows the method of connecting a meter for regular lighting service on a 250-volt, three-wire circuit, carrying up to 30 amp.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

* * * *

Using A. C. Generator as Synchronous Motor—What changes, if any, are necessary in order to use a stationary-field, revolving-armature, a.c. generator as a synchronous motor? This is a Westinghouse generator, rated at 25 kva., 480 volts, 30 amp., three-phase, 60 cycles, 1,800 r.p.m., serial No. 4212835. The exciter is direct-connected to the generator shaft and is rated at ¾ kw., 125 volts, 6 amp. I should like to use this generator as a synchronous motor to drive a centrifugal sugar drier and to correct power factor. The power supply is 480 volts and all motors are rated 440 volts. If I can use this generator as planned, what horsepower will be developed and what will be the ampere input? Will I have to have an outside supply of direct current for excitation, or can I use the exciter on the machine?

Negros Occidental, P. I. A. C. M.

In answer to A. C. M.'s question in the February issue, these machines are built to serve either as generators or motors, but must have a squirrel-cage winding when used as synchronous motors, or the starting torque will be very low.

When used as a motor, the machine in question will develop approximately 35 hp., and the current taken will be about 30 amp. The direct-connected exciter on the machine is all that you will need for excitation purposes. However, unless the connected horsepower load is small, you will not realize much from this machine as regards power factor correction because its capacity is very limited by reason of the small excitation current available from the exciter. I would suggest that you try out a set of static condensers for power factor correction if the machine does not help you out enough. Any reliable electrical manufacturer, such as the General Electric Company, or the Westinghouse Electric & Mfg. Company will gladly give you any information you wish. LEE F. DANN.

Chief Electrician,
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Determining Size of Conductors for Intermittent-Rated Motors—Will some reader of INDUSTRIAL ENGINEER please give a method of computing the sizes of rubber covered cables to be used for connecting intermittent-rated motors—particularly half-hour rated crane motors?

Montreal, Can. F. P.

In answer to the question by F. P. in a late issue, motor ratings for service of a periodic nature, or a continually recurring cycle of operations, can be calculated from the root-mean-square formula. This method is based on the fact that heating in a motor is proportional to the square of the load and the duration of the load.

Take a crane motor that develops 20 hp. for 5 sec., 30 hp. for 15 sec., 10 hp. for 15 sec., and 0 hp. for 25 sec.

Then:
$$20^2 \times 5 = 2{,}000$$
$$30^2 \times 15 = 13{,}500$$
$$10^2 \times 15 = 1{,}500$$
$$0^2 \times 25 = 0$$

$$17{,}000$$

The square root of 17,000 divided by 60 will give the approximate average horsepower required to complete the cycle, which in this case is 16.83 hp. In any event the cable should be large enough to safely carry the peak load of 30 hp. for 15 sec.

Goldfield, Nev. PHIL D. COMER.

* * * *

In a recent issue F. P. asked for information as to the proper method of computing the size of wire to be used in connecting up motors for intermittent duty, such as crane motors. This request came from Canada and I am not sure whether the rules of the National Board of Fire Underwriters are in force there as they are on this side of the border.

The National Electrical Code makes no allowance for intermittent work so far as the size of the wires is concerned, but requires that the maximum current carried shall be less than the allowable amount for that size of wire. The current value may be calculated from the table under Rule Eight in that code. If Canadian installations must conform to another code, it should be consulted.

Westfield, N. J. G. H. MCKELWAY.

* * * *

Lining Up Sprockets for Chain Drives—Can some reader tell me the best and simplest method of lining up sprockets or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.

Decatur, Ill. J. L. B.

Referring to J. L. B.'s question in a recent issue of INDUSTRIAL ENGINEER it appears that he has reference to silent-tooth chains.

To obtain long life and quiet-running chain drives it is important to have the shafts of the sprockets parallel and the chain guiding medium in line. Aligning both sprockets with reference to their face or guide-link grooves is easily accomplished by use of a straight edge or a piece of string, similar to lining belt pulleys. Also, by observing the drive in action, final adjustments can be made laterally by moving either the driver or driven sprocket sidewise.

One method of checking to determine whether the sprockets are parallel is to take a piece of ¼-in. or ⅜-in. cold-rolled stock, about 1 in. shorter than the distance between the outside diameters of the sprocket teeth and fit a micrometer thimble to one end. This gaging rod is then placed between the two sprockets at one end of the sprocket teeth, a reading taken and checked against one taken at the other end. This gaging is done between the top of one tooth of the driver and the top of a corresponding tooth of the driven sprocket. The shafts are then adjusted until the reading at each end or side of the face of the sprockets corresponds to within 0.005 in.

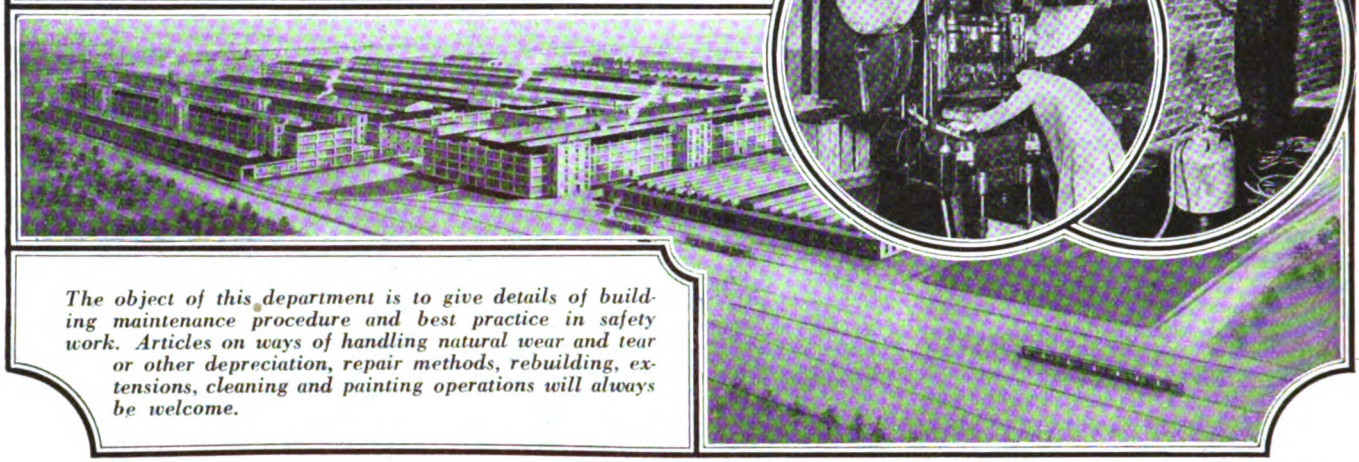
As an alternative, if the elements for the gaging rod described above are not available, a stick of wood may be used. This is cut about 1 in. shorter than the approximate distance between sprocket diameters and a nail driven in each end. The heads of the nails are cut off and the ends slightly tapered and rounded. In this case the gage is used in the bottom of the tooth, measuring at the bottom of the corresponding tooth in the other sprocket. The nails can be driven in to suit the distance at one end or side of the sprockets, using a piece of tin as a feeler-gage under the nail point, and checking on the opposite side, making the necessary adjustments for paralleling. Greater care and patience are required for accurate alignment, as compared to the first-mentioned gage rod, but it can be done.

Also I would suggest studying the article on silent chain drives which appeared in the August, 1923, issue of INDUSTRIAL ENGINEER. E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

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Building Maintenance and Plant Safety



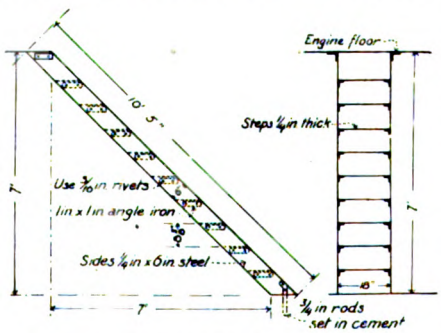
The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Strong and Simple Stairway for Use Around Machinery

WE HAD occasion some time ago to install two metal stairways, of the type shown in the illustration, in a power plant engine room, and they proved so satisfactory that a number of others of similar construction were built for other purposes.

When the engineer is called upon to make something of this kind, he has to do all the preliminary work for one job, unless he has such data indexed among the files of his trade papers or has happened to clip an article relating to that particular thing. As I had to do the necessary planning for this installation, the design used is presented here for reference. These stairways are easy to ascend, as the angle is 45 deg., which is unusually comfortable for an industrial installation, although this is a little steeper than architects in the building trades will specify.

Besides engine and boiler rooms, where metal runways, stairs and ramps are essential, there are any number of applications in the industrial field. In the manufacture of foodstuffs, cloth, floor coverings, artificial leather, and in many other lines automatic machinery of great length (and considerable height) is used for a number of continuous processes, and there is an upper deck that must be reached by ladders or stairways. The latter are far preferable and safer, and they are as low in cost.



Details of an inexpensive metal stairway for industrial plant use.

The design of stairway shown has ample safety for any load that can be put upon it by all the men who can possibly crowd on it at one time.

The side rails are made from ¼-in. by 6-in. steel. The ends are sheared at an angle of 45-deg. or they may be bent over to give additional support and for fastening. Pieces of angle iron are riveted to the insides and on top of these the step plates are laid and riveted. The step plates should preferably be of 8 in. width, although narrower plates can be used if there is any object in so doing.

Where it is possible to use it, corrugated plate is recommended for the step plates as giving surer footing for the workmen. A more elaborate design of step would include a riser at the back, set ½ in. above the step, to allow brushing out the dirt.

As shown, the upper ends are fastened to the engine floor, or deck. At the bottom, ¾-in. rods flattened out on top were riveted fast to the sides of the stairway and placed in holes drilled in the concrete floor; later the space around them was filled in with cement.

There are cases where such a stairway might develop an objectionable sway. Conditions of loading, vibration in machinery, or the use of thinner side rails might cause this. To combat anything of this kind, two diagonals on the back (under side) of the rails would stiffen the structure; or, riveting two or more of the step risers to vertically-placed pieces of 1-in. angle, would effectually steady the stairs.

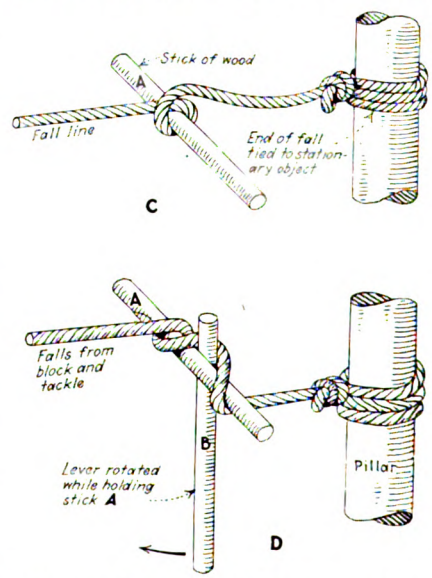
It would, of course, be advisable to erect a hand railing alongside this stairway so that a man could catch himself in case he should stumble or slip. In damp or oily places it is well to use a special safety tread. There are several makes of these available.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Using the "Spanish Windlass" to Increase the Pull

THE Spanish windlass has been found to be a big help where a tremendous pull is to be exerted in shifting heavy machinery into place with a block and tackle, and where it is not possible to get enough more men on the fall line to handle the load. Although it may not be new to the sailor or experienced rigger, perhaps some of the readers of INDUSTRIAL ENGINEER may find it a big help at some time or other.

All that is required to make a Spanish windlass is two sticks, preferably hardwood, of convenient length. The ends of the fall are fastened around a stationary object or pillar with a little slack in the line. Referring to the illustration, stick (A) is given a twist into the line so as to form a round turn of rope (C) about it. Stick (B)



How a Spanish windlass may be applied to the end of a fall line from a block and tackle in case a load gets stuck and the men available cannot move it.

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is then placed at right angles to (A). As will be seen, the rope comes across the back of (B) and on top of stick (A). Stick (B) is rotated as a lever in the direction of the arrow to wind up on the line. This operation is easily understood from the drawing.

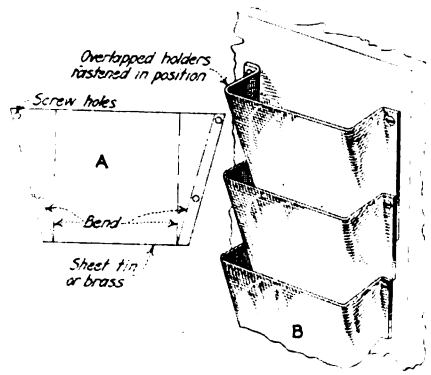
This arrangement is not intended to be used for making a long pull, but it is handy for giving the extra pull that is necessary when the weight is stuck and there is not enough "beef" available to make the grade.

Oakland, Calif. S. H. SAMUELS.

Simple and Easily Constructed Filing Rack

WHERE a vertical holder for cards or papers is needed, which will separate them in any desired order, the type of holder shown in the accompanying illustration can be made at practically no cost.

The individual pockets are made from a single piece of sheet tin or brass that is bent at the places shown at *A* to the shape shown at *B* in the accompanying illustration. The holders are held at



The holders are made of sheet tin or brass and bent to the shape shown. They are arranged in vertical columns to which parallel rows can be added.

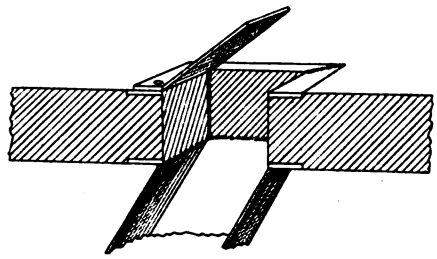
the edges with small screws or tacks. This form of holder permits of overlapping and can be arranged so as to form one continuous column as shown at *B*. If more pockets or holders are required, parallel rows can be added.

Washington, D. C. G. A. LUERS.

Trap for Floor Sweepings Which Aids in Factory Housekeeping

INDUSTRIAL housekeeping is ordinarily much more easily done if some provision is made in the plant for removing the sweepings and other debris. In woodworking plants, for example, it has been customary to have doors or slides opening into an exhaust pipe into which sweepings or shavings could be pushed so as to be automatically removed by the same suction which removes the shavings from the machine. Chutes could be used in many other industries for a similar purpose. In cases where the material is bulky, as in the woodworking industry, it would probably be necessary to put some suction on it, although for many lines of work a straight chute can be used with an open discharge at the end.

An ingenious floor trap for such dirt removal is shown in the accompanying sketch, through the courtesy of The Linde Air Products Co., New York City. This consists of a rectangular box of channels cast in the concrete floor, with flanges out and equal in depth to the



This floor opening for a dust or sweepings trap was built up by oxyacetylene welding and cast into the floor.

depth of the floor. These channels were oxyacetylene welded at the corners. An enclosed chute leading from this box to a waste material conveyor is welded to the bottom of this and the top is covered by a sheet steel door. When the floor is swept, it is merely necessary to open the door of this trap and push the sweepings into the chute. If it is to be used in connection with a suction line care must be exercised to see that it is a tight fit so as not to lose too much of the suction when not in use.

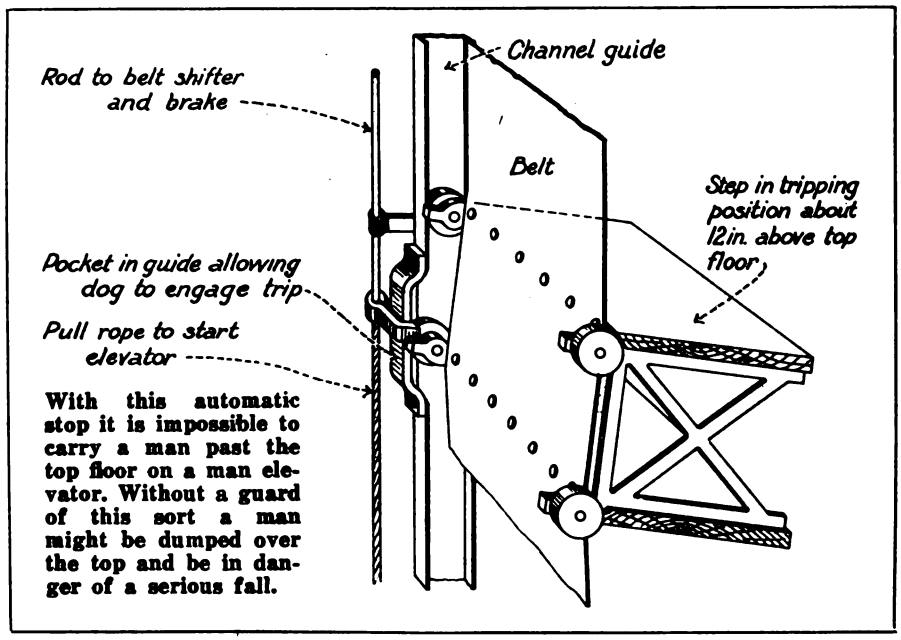
Stop Which Prevents Riding Man Elevators Past Top Floor

IN SOME food products and other similar plants, where the supervisory force and others connected with the industry must travel frequently from floor to floor, it is the practice to install what are known as man elevators. These consist of vertical belt conveyors with steps and hand holds. The belt is in continuous operation, so that a man may ride up on one side of the belt or down on the return side of the belt. For this equipment there are, in general, two styles of steps. One of these steps is so constructed that when it reaches the top of the flight it tips over so that it is in the proper position for the man to ride down on it. Sometimes however, these do not tip and when the man steps on it, may in some cases cause an accident. The other is a double type of step as is shown in the accompanying illustration. The hand holds are riveted to the belt at the proper distance on each side of the step.

These man elevators are safe and a big convenience in carrying a few men between floors. Otherwise, if a man had to wait for an elevator or had to walk the three to five floors between operations, supervising would be an exhausting job. Practically the only danger involved is through trying to carry tools or other objects up or down on the man elevators, or in neglecting to step off at the top floor. Supervision and discipline are perhaps the only methods of preventing individuals from carrying objects while riding.

At the Battle Creek, Mich., plant of the Postum Cereal Company an elevator of this type is installed in the five-story Post Toastie building. Here the special device shown in the accompanying illustration automatically shuts off the man elevator in case the person riding on it should neglect to step off before he has passed a foot above the top floor. It will be noticed from the accompanying sketch, that rollers supporting the step ride in a channel guide. A short piece of the metal is cut out of the side of one of the channels and a strap or pocket is fastened on, as may be seen.

When a man is riding on the elevator his weight forces the lower roller guide up against the side of the channel and when it comes to this pocket, throws out far enough to catch into a dog which trips the starting rope of the elevator. When the step is not loaded the roller goes straight past the pocket in the guide and does not trip.



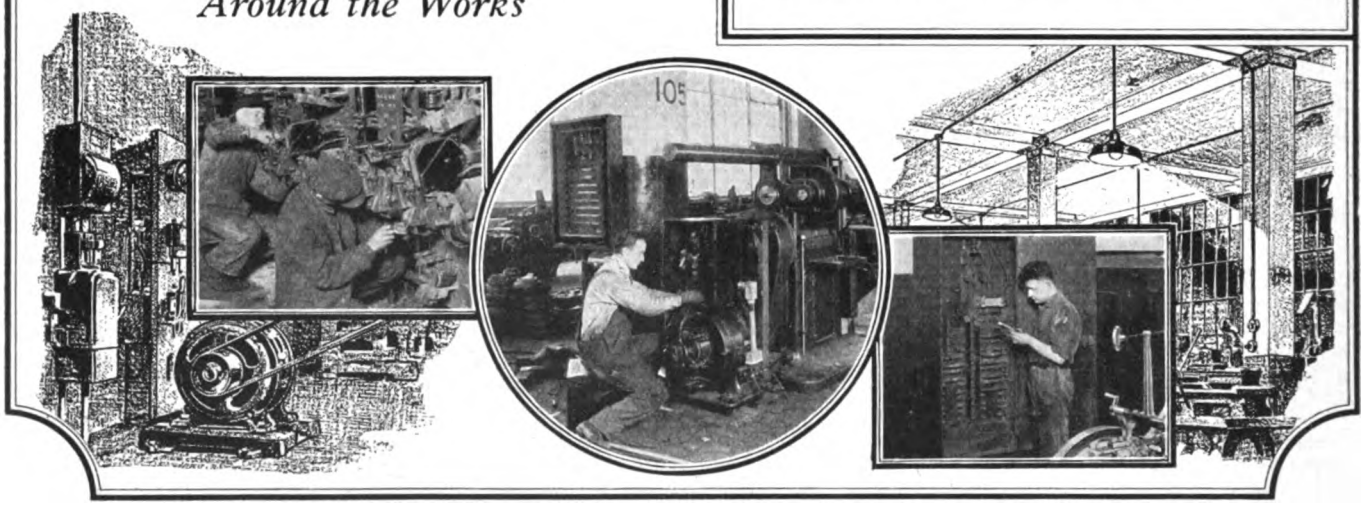
With this automatic stop it is impossible to carry a man past the top floor on a man elevator. Without a guard of this sort a man might be dumped over the top and be in danger of a serious fall.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Easy Method of Attaching Conduit, Cleats, or Bolts to Concrete

WHILE fastening conduits, knobs, cleats or bolts to concrete walls or ceilings may be done in various ways, it is often difficult to make a rugged and substantial job. We have lately been using a method that has proven itself a time and money saver and is hereby passed along.

In most industrial plants, compressed air is available and it is only a matter of a length or two of air hose to get it to the place where it is necessary to mount the material on the concrete surface. We buy star drills in quantities and machine the shanks to fit the sleeves of the air hammers. These, together with the air hammers, enable us to drill holes in concrete quickly at a very low cost. Wherever we think that we need to anchor a conduit, knob, cleat or other piece of equipment to the concrete, we drill a hole in it, and tamp the hole full of Smooth-On No. 1 (made by the Smooth-On Mfg. Co., Jersey City, N. J.) which is mixed with water until it has the consistency of soft putty. The knob, cleat, block or other device that is to be fastened to the concrete is then placed over the hole and a wood screw driven home into the soft Smooth-On. It is supported by a brace in this position for an hour or so and as soon as the Smooth-On has hardened it will be found impossible to pull screw, fitting or block loose.

For conduit work we prefer mounting wood blocks on the concrete and fastening the conduit to the blocks, thereby giving clearance for turning the conduit fitting.

We prefer the Smooth-On to lead anchors or expansion bolts for the reason that the size of the drilled hole in the concrete is important when using expansion bolts or lead sleeves, whereas with the Smooth-On it is immaterial.

It is also possible to mount bolts in concrete by drilling somewhat larger holes and setting the head of the bolt in the hole and tamping it full of Smooth-On, leaving enough of the bolt extending beyond the face of the concrete to allow for attaching anything that is required.

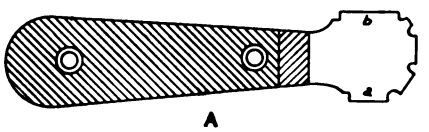
We are convinced that this method makes as strong a support in concrete as is secured by anchor bolts and sleeves and surely it is much cheaper and faster. Holes that are a little out of line can be used by enlarging them until they are in line and then filling both the hole and the mistake with the Smooth-On.

Plant Engineer, S. W. STEARNS.
Gardner Machine Co.,
Beloit, Wis.

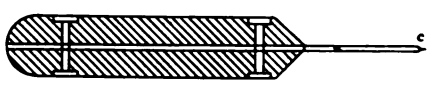
Handy Tool for Inserting a Renewable Fuse Link

THE accompanying sketch shows a handy tool for inserting renewable links in Economy renewable fuses. It has been found in practice that some tools commonly used do not press the end of the links tightly enough into the containers. When a screw driver is used the slotted plugs are badly mutilated.

The sketch is self-explanatory. The bit, which runs through the riveted handle, is made of finely tempered steel. Instead of the edges being tapered, they should be ground as shown in (B), which lessens the tendency for the bit to slip out of the slot.



A



B

This tool renders it possible to make a firm contact when inserting renewable fuse links.

Portions (a) and (b) of sketch (A) are used for 30-amp. and 60-amp. sizes, respectively, as these sizes require a greater leverage to make a firm contact.

W. L. STEVENS.
Construction Engineer,
Smith Robinson Co.,
Vancouver, B. C.

Break in Power Line Cause of Obscure Trouble

A VERY puzzling incident came to my attention a short time ago, which I think may be of interest to readers of INDUSTRIAL ENGINEER. A 10-hp. d. c. motor operated on 500 volts had been sent to the shop to have the armature rewound. It was the only motor the owner had operating at this voltage. After the repairs were made, it was tested at the shop, proved to be in first-class condition, and was finally set up on the job. When the current was switched on, the armature refused to turn. The belt was removed, the bearings tried, fuses tested and connections checked, but without any results. A man from the Public Service Company was called in twice and claimed everything was all right up to the service switch.

We had spent about a day on it so far and felt stuck, good and plenty, but there was still one thing left for us to try and that was to measure the current to see if we were really getting enough power to run the motor. A meter was not available; so we fused across the main switch with 10-amp. fuse wire, threw in the switch, and the fuse wire held. Of course that told us our trouble. The Public Service Company was again called and their man tested the line with lights the same as we did and told us the line was O. K. so we had to convince him that it was not. This time we shorted the main switch with a screw driver and when nothing happened he called their repair truck. After tracing the line back, they discovered a broken wire lying in water in a manhole. That showed us why we had lights, but no power. After

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repairing this break everything turned out satisfactorily.

This puzzling trouble can be told quickly, but it took us about a day and a half to get this motor running.

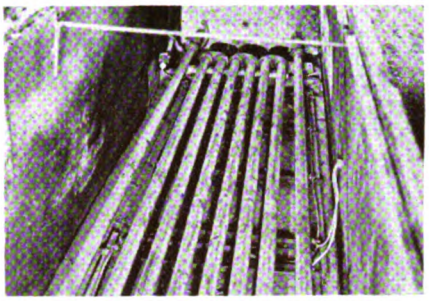
WALTER C. BISCHOFF.
Nesbit Electric Co.
Newark, N. J.

How Electric Heat Supplanted Steam for Preheating Wood Before Gluing

IN MANY high-grade woodworking plants it is the practice to preheat the wood before gluing to secure a tight bond. It is thought that preheating opens the pores in the wood so that the glue when applied penetrates the wood and makes a better joint. This is the practice at the Boston, Mass., plant of Horn Brothers who manufacture cabinets and interior finish.

For a number of years a steam-heated box had been used for this operation. It was necessary to operate a small steam boiler during the summer months for the heating of only this box and the glue pots. About a year ago, it was suggested that a saving could be made by heating this box electrically instead of by steam. The top of this box, which is 12 ft., 6 in. long by 2 ft., 6 in wide by 2 ft., 6 in. deep, is divided into two sections so arranged that either can be opened as desired as shown in the accompanying illustration. The interior of the box is lined with asbestos which is protected by sheet metal. The steam coil is in the bottom, as is also shown.

As it was the original intention to heat the box in summer by electricity and by steam in the winter, the steam coil was left intact and the electric heating elements placed at right angles underneath. As there are about 34 sq. ft. of steam pipe radiating surface in the coil, it was estimated that about 2½ kw. of electrical capacity would be sufficient to maintain the desired temperature. In order, however, to reduce the time of heating up in the morning, 4 kw. were installed in eight units of 500-watt, 230 volt, Westinghouse space heaters. These were so arranged on a double-throw switch that either full or half-heat could be secured. After the equipment was in operation it was found that it was necessary to leave the high heat on for only a short time in the morning. The switch could then be thrown to the half-heat position.



This view of the interior of the box shows how the space heaters were placed.

At the time the wood box was arranged for electric heating it was also decided to do away with the steam-heated glue pots. A circuit was run along underneath the work benches with outlets arranged at convenient points. Two 1-qt. and one 2-qt. Westinghouse electric glue pots were then installed. This arrangement proved much handier for the workman, for he had the glue at his bench. It was not necessary for him to walk across the room as he did when the steam-heated pots were used.

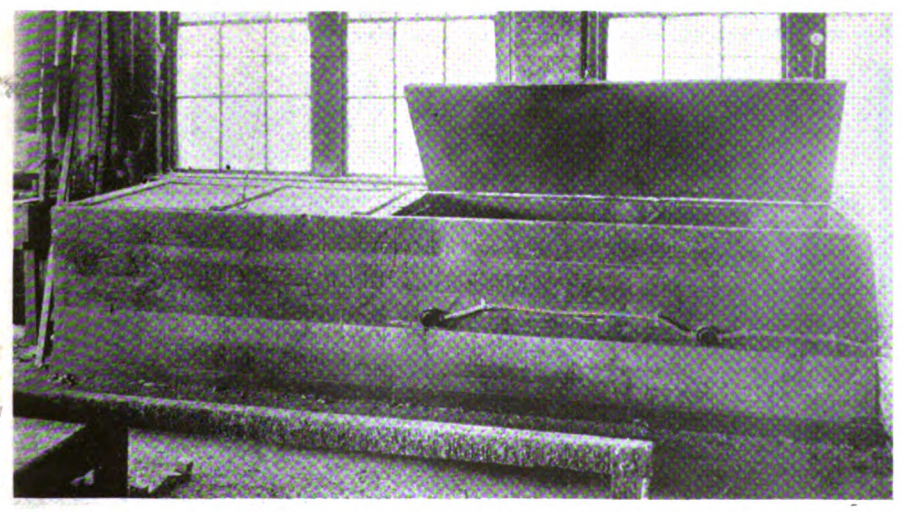
Although it was the original intention to use the electrical equipment only during the summer, experience showed that the operation was so economical and convenient, that the owner is now considering using the electrified equipment the year round.

The cost of this installation amounted to about $225 including three glue pots, 8,500-watt space heaters, and all necessary wiring including a run of about 50 ft. of wire from the service entrance. The average monthly energy consumption of this equipment is 370 kw.-hr. which at 3 cents per kw.-hr. amounts to about $11. J. L. FADEN.

The Edison Electric Illuminating Co.,
Boston, Mass.

Formerly steam was used in this box to preheat wood for gluing.

This required that a steam boiler be operated during the summer. Now, eight 500-watt space heaters with a double-throw switch so that half of them can be turned off after the box is heated up, were installed beneath the steam coil. It now costs about $11 monthly to heat this box and three glue pots with electricity, which is much less expensive and laborious than keeping up steam in the boiler.



Importance of Proper Design in Illumination of Factories

UNTIL the past few years man has, when using artificial illumination, been accustomed to local lighting from small and few (usually one) light sources. He has therefore, with good reason formed the mental habit of believing that the nearer his eye and his work are to the source of light, the better will he be enabled to see. However, the very conditions which formerly enabled him to get the best results from his lamp may now constitute the least efficient arrangement.

Lamps are now so large that they need not be so near the object lighted in order to give good illumination. They cost so little that a number may be used with a more than proportional increase in results. Also, they are now so bright that they should no longer come within the range of vision, or discomfort and injury to the eye will result. Therefore, the lighting habits of generations must be broken if we are going to make the best use of our eyes.

Before we started using artificial light we had the general illumination of the sun; to this light we were physically very well adapted. Our eyes are shaded by our brows from the glare overhead, and are able to adjust themselves to the slowly changing intensity through the day.

Our artificial lighting habits were against the laws of nature, but as we did not know how to make very good lamps, it did not matter much. But now that our present lamps produce light of an intensity more comparable to sunlight, we are being forced to change some of our habits.

Properly designed lighting systems are now as good as sunlight, and sometimes better. These are systems of general illumination using a number of large-sized luminaires mounted relatively high and so spaced as to give a uniform lighting of the working plane. No other system can be better for any useful application. A good general illumination produces the effect of working out-of-doors, with the sunlight not too bright. When the work to be done is of such a nature that the illumination from the sun would not do, local lighting must also be used. If light must be projected into cavities or under objects, portable or adjustable brackets are required. The light must be well shaded from the eye, or the undesirable effect of the glare will more than counterbalance the value of the additional illumination obtained.

Glare in the eyes in time injures them or at least affects the vision. Injury also may be caused by too intense light entering the eye or by the alternate reception of light of moderate and low intensity. Glare effects may be produced by direct or reflected rays, when the lamp filament or its reflection comes in the line of sight. They may also be

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produced by a flicker of the light or by the cone of vision covering alternately fields of higher and lower illumination.

For the above reasons, lamps should be hung above the range of vision or else shaded or screened; glass should not be used on desk tops; 25 cycle or fluctuating voltage should not be used for office lighting; belts, spokes of wheels, or other parts of moving machinery should not be permitted to produce flickering where any fine work is to be done; and local lights should not be used on desks or drafting boards. When local lights are used they should not produce a greater illumination than that received from the main lights which they supplement. In industry local lamps should be employed only to obtain light rays at an angle to those giving the general illumination.

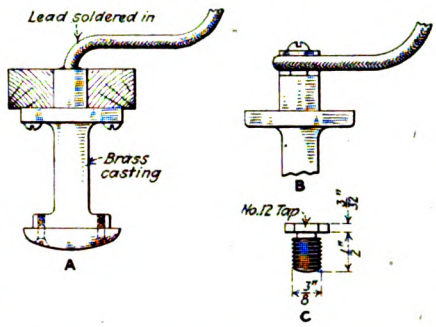
Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corporation,
Pittsburgh, Pa.

How Starter Trouble Was Cured by Applying a Little Common Sense

AT ONE time we had a 10-hp. induction motor with a General Electric Type CR, starting compensator which will be recognized as quite an old timer. This compensator had always given trouble through breaking of the leads to the cylinder. About once a year we would have to shut down the woodworking room served by this motor while the starter was being fixed up. The shutdown meant, in addition to the half-day's work of making repairs, a wait of one to four days to get an electrician, as we then depended on outside help for work of that kind.

On one occasion this starter went bad again at a time when we couldn't get anyone to fix it right away and we just could not wait. We decided to tackle the job ourselves; so we took the whole thing apart, carefully marking each wire as we went along. Sure enough, two leads were broken off where they entered the shoe sockets.

The leads were soldered in a hole in the brass casting as shown in the diagram *A*. Two disadvantages appeared to us in this construction. The wire had to be bent sharply in order to enter the socket, and with the soldered fastening there was no chance to make repairs except by dropping the cylinder out of the case and pulling the leads along with it. If the bend were avoided there would be no initial stress on the wires to start a break and if a screw fastening were adopted, repairs could be made by merely taking off the front cover of the compensator, with no wires to thread in and out and no oil pan to handle.



Originally the leads to the cylinder of starting compensator were sweated in as in A. The change in B, using a screw connection, eliminated lead breakage and made quick repairs possible.

We altered the fastenings of all the nine shoes as shown at *B*. It took a little time in the machine shop to make the necessary parts but it was a good job when completed and we saved something by not having to sweat in all the wires. The holes for the reception of the leads and solder, were tapped out and into these we screwed brass bushings that had hex. heads of ample diameter. On top of these, the leads were to be secured by a conventional brass screw and washer. These screws headed upwards and when the compensator was re-assembled, they could still be worked at by using a long screwdriver. As noted in the drawing, the changed construction allowed the leads to enter and be fastened at an easier angle than before, while the sharp bend where they had broken so often was avoided altogether.

Long usage since then has shown that the change was a good one, for no more leads have broken. The men in the shop have remarked that they wish a wire would break just to give us a chance to demonstrate how easy it would be to make repairs, in contrast to the old, familiar delays. This alteration saved the company the cost of a new starter, for one was about to be purchased because of the high upkeep of the old one, but now the starter is apparently good for our lifetime.

This same trouble of wires breaking is very annoying in a busy department (and who ever knew of any breakdown to occur where the department wasn't busy?). Long experience has shown one way to avoid these continued breaks. It is customary to cut back the insulation and stick the wire on again. Then the first thing you know, the wire is a bit short, and the constant bending back and forth that a cylinder wire gets can be made serious in no quicker way than by having it occur on a taut wire. The remedy is to splice the wire or put in a long lead, so that there is plenty of slack; the wire will then stand twice the amount of flexing before it finally breaks.

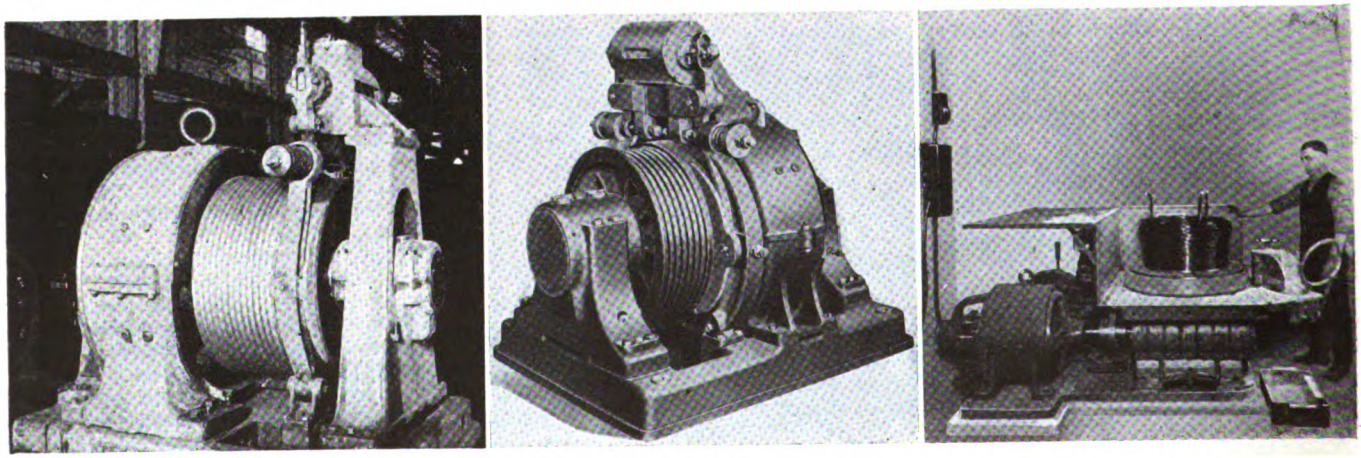
DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Correction in Article "Electrical Devices in the Path of Power Service"

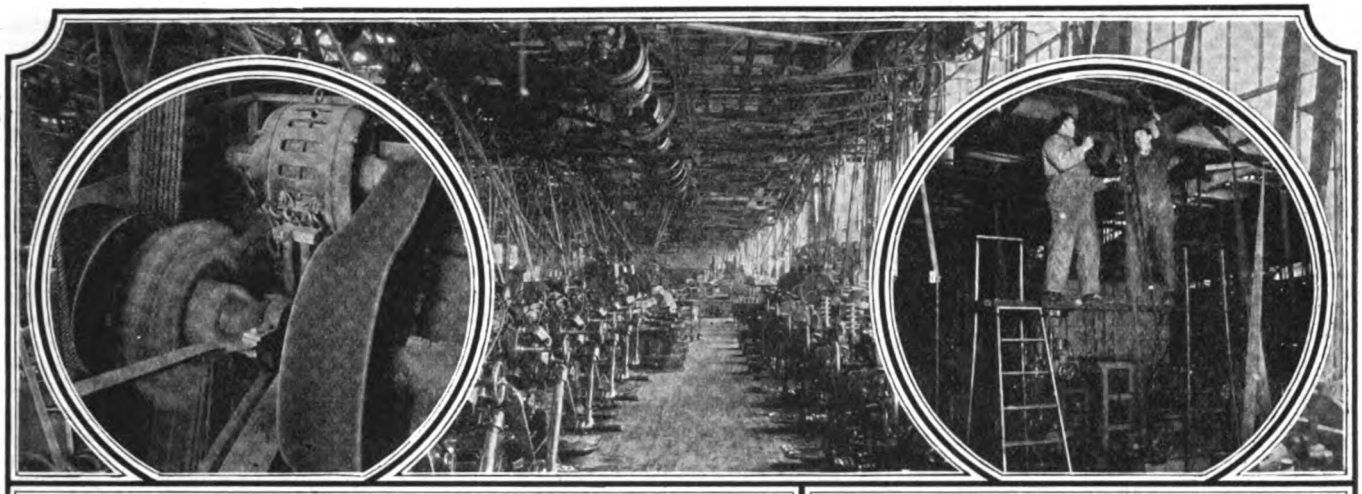
AN ERROR was made in the caption to the illustration on page 75 of the February issue of INDUSTRIAL ENGINEER. In this caption the words "left," "middle," and "right," were inadvertently interchanged, thus incorrectly crediting the three manufacturers with the equipment illustrated. The corrected caption and the illustrations are shown below.

Three motor drives that were designed to fit the user's special requirements.

At the left is shown a log carriage drive developed by the Westinghouse Electric & Manufacturing Company. The motor shown is rated at 35 hp. with a speed range of 10 to 80 r.p.m and is supplied with variable-voltage, direct-current power from a 30-hp., motor-generator set. In the center illustration is shown a new gearless, traction elevator motor built by the Allis-Chalmers Manufacturing Company of Milwaukee, Wis. This is a slow-speed, shunt-wound motor, the armature shaft of which is coupled directly to the hoisting drum. At the right is shown a special variable-speed, motor application made by the Reliance Electric & Engineering Company of Cleveland, Ohio, to a wire drawing machine. It is said that increased production is obtained with this individual drive arrangement.



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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Record System For Spare Pulleys and Other Transmission Equipment

FOR a number of years I have used the following system for keeping a record of spare pulleys and other transmission equipment and have found that it enables me to locate all such equipment quickly.

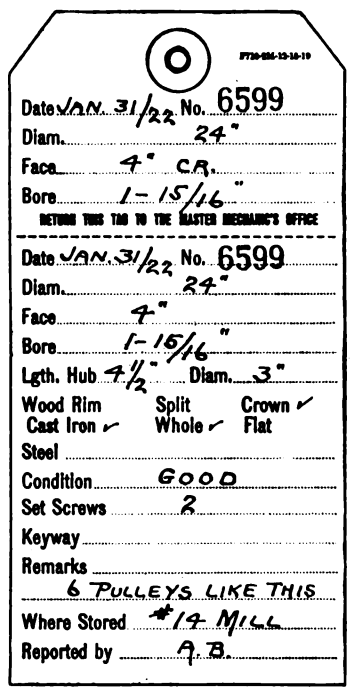
Every pulley, gear, coupling, or other piece of transmission equipment is given a number upon being placed in storage. This number is painted with white paint on the face, arms, hub or side in sizable figures. Upon a cloth tag fitted with a tie wire instead of a piece of string, is entered all of the data regarding the piece of apparatus that is being numbered. This tag is shown at the left in the accompanying illustration. It will be noticed that this tag has a perforated line across the upper third. After the tag is filled out, the two parts are separated at the perforation, the upper part with the wire is attached to the pulley or other piece of apparatus being recorded, while the lower and larger part is placed in a file in the office of the foreman of the machine shop. In this file the tags are grouped according to pulley diameters or some other distinguishing size.

The same data that was entered on the tag is entered on a 3-in. by 5-in. card as shown at the right in the illustration. This card is kept in a file in the office of the superintendent of the *Mechanical Department*, the office in which all the engineering work is planned and laid out.

Whenever a pulley or other piece of transmission equipment is taken from storage and put in use, that part of the tag that was attached to the pulley is removed and taken to the office of the machine shop foreman. Here the corresponding part of the tag is taken from the office files and the two parts are taken to the mechanical superintendent's office. The proper 3-in. by 5-in. card is then taken from the file in the mechanical superintendent's office and this card with the two portions of the tag are destroyed. In this manner both the machine shop's and the mechanical superintendent's files show only those pulleys or other apparatus that is in storage.

The same system can be used for hangers, couplings, gears, motors, pinions, in fact, for any class of spare material held in storage, the only change necessary being in the data entered on the tags and cards. One important point to be noticed is that in storing the spare equipment it should be so placed that the numbers which are painted on it are plainly visible. If possible, it is well to group the apparatus according to types or size of apparatus.

Lawrence, Mass. A. J. CALHOUN.



Easily Installed and Simple Method of Handling Long Belt Drive

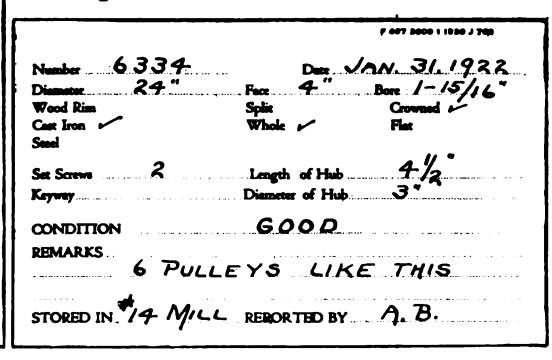
IN a certain printing plant a battery of cylinder presses is installed along one side of the room. These presses are driven from a line of shafting hung from the bottom chord of the roof trusses and placed close to one wall. The center of the room is used for storage of paper and printed matter.

The growth of the business necessitated the installation of some small auxiliary machinery, such as stitchers and stapling machines. These are light power machines that are usually placed flush with the front edge of a bench, so that work can be handled from one side to the machine and then passed out of it and on the other side of the bench without any lifting or unnecessary piling.

These light machines were installed in two sets near opposite ends of the

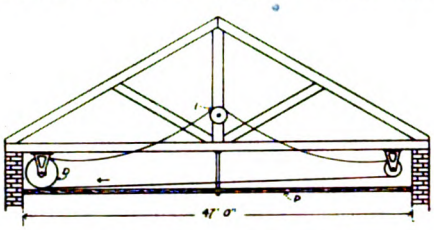
All data regarding the pulley is placed upon the tag shown at the left.

The upper third of the tag is tied to the pulley and the lower part is placed in a file in the machine shop foreman's office. The data on the tag is also entered upon the card shown at the right. This card is filed in the mechanical superintendent's office where all of the engineering work is planned and laid out. In this manner both the engineering department and maintenance department have a record of all pulleys that are in storage.



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room and in connection with benches along the wall away from the cylinder presses. The arrangement was ideal from a material-handling standpoint. Power was to be supplied to the two



The slack side of the belt was supported on an idler pulley, to keep it from dragging on the running side.

sets of machines by belts from the line-shaft, a short overhead shaft having been installed to serve each group.

The illustration shows the belt drive which was eventually adopted. It was worked out by the master mechanic after the direct drive which had been originally planned had failed from dragging of the belts. The room is nearly 50 ft. across and, as every engineer knows, the sag in a belt between such centers is considerable, even though it be stretched too tight for proper free running.

The pulley (D) is the driving pulley; it was made as large as possible. The driven pulley is much smaller. A stout plank, (P), runs underneath for safety and takes care of any undue sag in the driving side which is, fortunately, on the bottom. An idler, (I), raises the upper or slack side of the belt free and clear.

This belt drive is free-running and neat; it requires no attention and overcomes in an ingenious way the risk of tangling that is always present when two long belts touch, or the slack side touches the running side of the same belt. The arc of belt contact that is obtained on both the driving and driven pulleys is all that could be wished.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Two variable-speed power transmission units used on a body conveyor.

These are two of 18 similar installations in the plant of a Detroit automobile body manufacturer. The saving over the use of variable-speed motors on the 18 installations is $864.54 a year as explained, with other advantages, in the accompanying item. In the installation at the left the motor is connected to the Reeves variable-speed drive, shown at the top of the framework, through a silent-chain drive. The variation in speed is obtained by a V-belt on two sets of cones. As the cones are forced farther apart or closer together the belt rides lower or higher on the cones and so decreases or increases the diameter of the pulleys, which varies the speed ratio between them. To obtain the slow conveyor speed a further reduction, in a fixed ratio, however, is obtained through the roller-chain drive to the Palmer-Bee (Detroit, Mich.) mill-type speed reducer and the roller chain from it to the large gear in the floor which drives the conveyor. The installation pictured on the right is similar except that it has belt instead of chain drives and uses a Palmer-Bee worm speed reducer. Most of the conveyors in this plant are operated at a speed varying from 13 in. to 40 in. per min. even though driven by a constant-speed induction motor.

Savings Made with Variable-Speed Transmissions on an Assembly Conveyor

VARIABLE-SPEED transmissions enabled a Detroit automobile body manufacturer to reduce motor sizes 33⅓ per cent and effected a power saving of nearly 1 hp. on every conveyor. The savings from these sources totaled $864.54 a year, which was a 41 per cent return on the investment, also with these transmissions, production can be scheduled more closely. Under the former method of production, bodies went through the shops on trucks, but the installation of a few conveyors quickly proved the economies which could be effected, and as a result 12,000 ft. of conveyors were installed.

These conveyors handle the bodies during paneling, painting and trimming operations. Their use effected a 10 per cent saving in labor, which meant 500 men, whose annual wages would be $975,000. Also, production was doubled with practically the same floor space. This saving was 250,000 sq. ft., worth $250,000 a year, which brought the total saving to $1,225,000 a year, not including interest on reduced inventory.

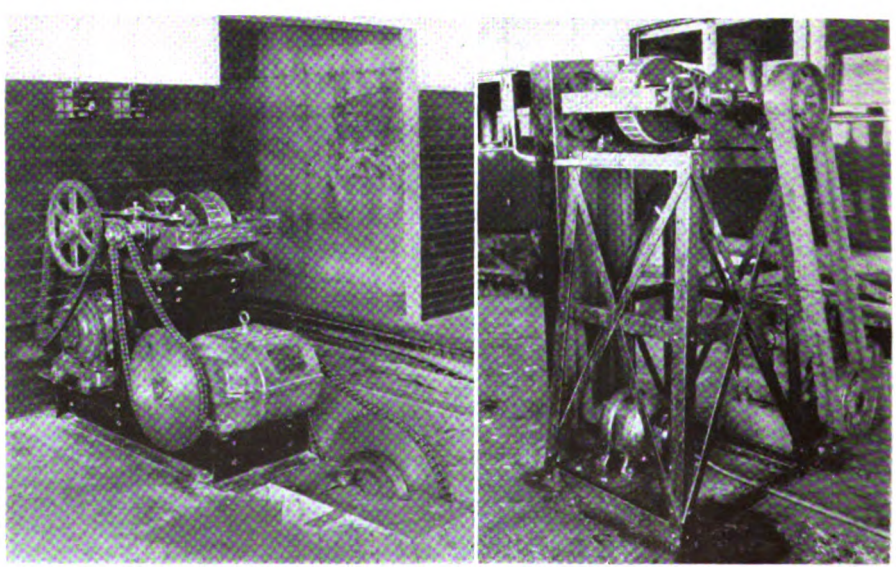
One of the most important factors in the success of a conveyor is the ability to control its speed accurately, for the speed determines the rate of production. For this work Reeves variable-speed transmissions (Reeves Pulley Company, Columbus, Ind.) were used, of a size capable of transmitting 6½ hp., at minimum and 10½ hp. at maximum speed. The maximum speed variation is 3 to 1. Conveyor speeds range from 13 in. to 40 in. per min.

Turning a handwheel on a transmission unit varies the conveyor speed over the entire range, in steps of less than 1 r.p.m. The exact speed desired can always be obtained almost instantly. This is quite a contrast to the former method of driving with variable-speed, alternating-current motors, most of which were equipped with common rheostats giving only eight or ten speeds. With this system the desired speed was not always obtainable, and even when it was secured it was subject to considerable variation as the conveyor load changed. Securing the desired motor speed was rendered difficult by the fact that each step on the rheostat produced a different increment of speed. Another disadvantage of this method lay in the fact that the motors required considerable excess capacity at rated speed in order to carry the load at low speeds.

By using these transmissions, these large, expensive, variable-speed motors and their rheostats were replaced with smaller, constant-speed motors. The average conveyor now uses a 2-hp. motor in place of the former 3-hp. motor. This saves about $60 on each motor, or $1,080 on the 18 motors installed. The savings in depreciation, interest, and repairs, due to this smaller investment total $197.64 a year.

There is also a saving in power, because the variable-speed motors are inefficient at low speeds; the loss in power is estimated at 0.75 kw. per motor, or nearly 1 hp. This means a saving of $666.90 a year in power, which brings the total saving to $864.54 a year. These savings will repay the entire original cost of the variable-speed installations in less than 2½-yr. The operating cost of the 18 transmissions is only $1.22 per day, a trifling amount to insure maximum results from a conveying system which saves more than a million dollars a year.

One of the greatest advantages of this transmission installation is that it enables production to be scheduled more closely. The schedule varies between wide limits; on some days production is three times as much as it is on other days. The transmission is set to give exactly the desired speed, and it will remain at that point. With the alternating-current motors this was impossible. Some plants vary the conveyor speed by changing pulleys. Obviously this method involves an expensive delay. It is suitable only where there is but one product and a constant production rate.



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Some Reminiscences on Mechanical Repairs That Show the Value of Experience

HOW we used a piece of sewer pipe for a pattern, in place of making a wooden one, is a "kink" that saved us quite a little money on the first job and more on later ones. To lead up to this, however, it might be explained that the Jones Shirt Company asked us to make a set of new piston rings for their engine. The piston was cut and we were told that we could come and measure it up at any time. We were under the impression that they had been running by steam all the time and so we hurried up there to get the work under way without delay. Upon arriving, it was disclosed that the plant had been operating for some time with electric power. A former management had hooked a 50-hp. motor to the lineshaft which supplied power to sewing machines and other equipment on the two floors. It seemed that the motor had been installed when it was found that the steam engine was taxing the capacity of the boiler.

This had been done in the Spring, when the days were long, and considerable economy had been effected. Then, in the Fall, they had hooked up to the public service for lights and had never again checked up on their total expenditures for power, heat, and light. The steam engine, in the past, had furnished power to the shafting and had driven a lighting generator from one of the flywheels. Steam could not be dispensed with as it was needed for pressing, steaming, and some other work, one battery of machines requiring steam at 90-lb. pressure. In view of this latter fact, the use of some motive power other than an engine should not have been undertaken without exhaustive proof of the need.

A new manager had investigated and found that his public service bills for light and power were relatively high. He found also that the boiler had a surplus capacity 'way beyond what was needed for heating purposes upstairs, and he was keeping a skilled man merely to attend the boiler. So, after quizzing some of the men who had known of former conditions in a general way, he had the piston removed for investigation and found what he had suspected: namely, that the amount of steam required for the engine had been due to leakage past the piston rings.

The engine cylinder was 9 in. by 12 in. There were two steam rings with the usual flat-lap rings of ½-in. square cross section. In their natural position, outside of the cylinder, the rings calipered hardly 9 1/16 in. and there was a ¾-in. notch at the lap, poorly fitting. It was little wonder that the steam had blown by. Rings for a 9-in. cylinder should measure 9 3/16 in. before compressing, in order to have the necessary spring to keep them steam tight.

A 9-in. cylinder was something that we had never fitted before and we had no pattern for the rings; nor could we find anyone else who had; nor could anything we had around be doctored up for this purpose. The management wanted two extra rings made at the same time. That meant a pattern about 5-in. long. The cost of making such a pattern was out of proportion to the rest of the job and some other way was sought. It ended in using a piece of sewer pipe.

We found that 8-in. sewer pipe measures just 8 in. inside and that the outside diameter is 9 1/16 in., both by shrink rule. This was exactly what we would have made our wood pattern, had we been forced to it. We bought a length of this tile pipe for 28 cents (a length that had a broken bell end) and cut off a section about 9 in. long, using a chisel for nicking all around, breaking off our piece, and then grinding the ends fairly smooth.

This was our pattern. We had purposely cut a piece longer than was absolutely necessary in order to give the molder something to handle in lifting, and to avoid the almost certain breakage had we attempted to cut off a ring only about half as long.

The only fault with the ring as cut off was its roughness. This roughness is found on all clay products of this sort, but in somewhat exaggerated form on tile pipe. These pimples all over the surface could not be filed off—glass hard from the kiln—and we had no good way of grinding them and actually bettering the surface. The piece was given to our machine painter with instructions to "apply three thick coats of machine filler today and sandpaper inside and outside smooth tomorrow morning." He did—and we had the nicest kind of a pattern. And not long after we had a call for the same size ring from some one else.

As there are many engines of the 9-in. bore in use, this kink will be of value to others who are faced with the problem of a cheap pattern that must be charged against the one job. The total amount of labor on this pattern was one hour, exclusive of the trip to the tile yard. The fact that the tile pipe is measured on the inside, and runs close to the nominal size, makes other sizes available for piston ring patterns. Note that the machined sizes required in the above case were 9 3/16 in. and 8 3/16 in. and that the tile diameters leave just a nice amount of metal to cut off. The inside diameter of the blank comes a little smaller from the jarring a molder gives the pattern to loosen it from the sand.

This is an illustration of one of those cases which are in the minority—where steam is cheaper than electricity. If the engine and generator had not been on hand, the case might have been different, but both had been put in years before and were still in splendid condition—a N. Y. Safety Steam Power engine and a Triumph (Chicago) lighting generator. There are many industries that require steam for processes but not many that have to use high-pressure steam; when they do, and when there is sufficient boiler capacity, the matter of steam power should be thoroughly considered before changing.

This is also an illustration of the high cost of taking some one's word without investigating. Some ex-engineer had reported that the engine used so much steam or that it cost more for steam than it would for electricity, all without knowing why so much steam was used. The manager, it must be said in his defense, had taken the man's word for it, thinking he was competent and not having the time or the knowledge to prove things for himself. More than that, he was used to electric power and knew its low cost and freedom from attendance charges; hence he bought a motor for the plant. Not until the new manager came along, with either more time or more determination to dig into the facts, did the real state of affairs come to light.

The writer ran across a parallel case some time back when measuring for piston rings in a piano factory. The steam engine ran lineshafts on the lower floors and drove a generator supplying power to motors on the three floors above. What was his surprise, on taking the piston out of the engine, to find that there were no rings in it at all. When the superintendent was called in, he explained that six years before they had paid (and paid well) to have the engine overhauled and new rings had been one of the stipulated jobs. Both this man and the proprietor doubted the writer's word that rings were supposed to be in the slots. They thought that the bull ring was the necessary part.

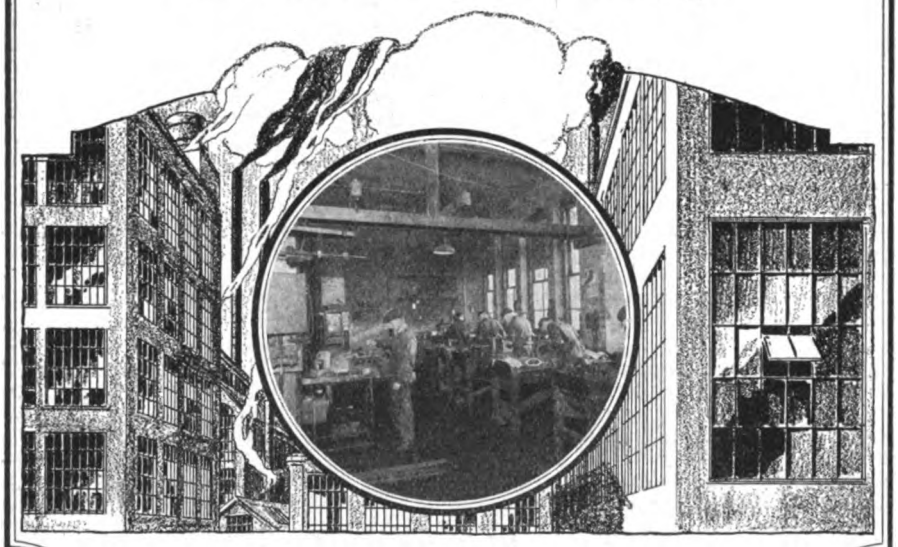
However, there had been a great deal of steam used and permission was forthcoming to make up the split rings. In due time they were installed, the work being done at night. Early the next morning, there was a phone call from the proprietor to say that everything was fine and the thing which had worried him most was entirely remedied, this being the great amount of steam that had gone out of the exhaust.

In these electrical days we are so used to snapping a switch or pressing a button that we are stuck when something puts electricity out of our reach. There was a plant not far from us that was located along a good stream. They had their own hydro-electric system furnishing power to machines located on different floors. They also had a pair of boilers for steam purposes and there was a steam engine standby that could be belted to the generator if necessary. It hadn't been necessary for several years, but at last a drought of several months' duration made the engine necessary. The handy man around the plant had been instructed to get things ready and he had oiled up, put a wrench on all the bolt heads one way or the other (including the eccentric and the valve stem) and was ready to start. His way of starting, and of getting the right direction of rotation, was to have some one turn the engine over while he gave her steam—then, "whichever way she was started she would go." Well, she went the wrong way for the generator and two men on the flywheel couldn't make it go the other way. That's how we came to get a hurry call to come and adjust the engine.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.
Middletown, N. Y.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Novel Use of Revolution Counter in Winding Coils

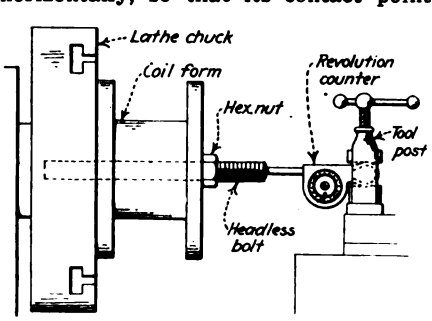
RECENTLY the writer had occasion to call into use a unique arrangement which may prove interesting to some of the other readers of INDUSTRIAL ENGINEER.

A certain job called for the rewinding of a circular field coil of quite large dimensions. It was necessary to have exactly 1,035 turns of wire on the coil. Anyone who has had experience in winding circular field coils knows the impracticability of counting the turns as they go. There are various reasons for this; the shape of the coil for one and the great number of turns for another. The method used by the writer was as follows:

The head of a ¾-in. by 12-in machine bolt was cut off. This headless bolt was securely locked in a lathe chuck and the coil form placed on it as on a shaft. The form was locked on its shaft by means of a ¾-in. hexagon nut. Next, a center was drilled into the end of the bolt. A revolution counter was then clamped in the tool post, horizontally, so that its contact point fitted snugly into the center of the bolt. This arrangement registered every turn of the form, allowing the winding to be done at greater speed than would otherwise have been possible, with a consequent saving of time on the job.

MAURICE M. CLEMENT.

Long Beach, Calif.



The revolution counter was held in the tool post of the lathe, with the end against the shaft supporting the coil form, to record the number of turns wound on the coil.

Composition and Ageing of Insulating Varnishes

IT HAS been shown that during the natural oxidation of oil varnishes for a period of time the resistance of a varnished insulation may decrease. This decrease in resistance is the result of formation, by oxidation, of low-resistance materials, chiefly acids of lower molecular weight which are volatile and form conducting solutions with water.

A number of factors influence the amount of these low-resistance materials very markedly and in making an examination of varnishes for insulating purposes the test must be made under fixed conditions, in order to obtain comparative values. The results to be described were obtained by taking cotton strips, standard insulating tape, and dipping unit lengths of this tape (one meter) into the varnish and allowing them to drain. Under these conditions the average insulating varnish has become air dry in 48 hr. and some of them in 24 hr., as shown by the stoppage of weight loss due to evaporation and the physical condition of the tape. The various varnishes yield a varying quantity of varnish gum depending on the nature of the varnish. In carrying out the examination for acidity a check is, therefore, obtained on the rate of drying and the body of the varnish.

Enough strips were prepared so that a sample could be taken on successive days over a period of time. Certain of the samples were exposed to the air at normal temperatures while a corresponding number of samples were baked at 100 deg. C. (212 deg. F.) in order to obtain a comparison of the effects produced.

Inspection of the results showed two things. First, that the amount of acidity formed is really a function of the time, increasing as the oxidation progresses. Other results indicate that for most varnishes the oxidation increases up to 96 hr., but after that it is practically complete, where we have a thin film. The second fact shown is that the values are really characteristic for the particular varnish. While the quantity increases with time, the order of the different samples remains essentially the same so that, for purposes of comparison, a 48-hr. test period is as good as a 96-hr. period.

The table of results was obtained on especially-prepared samples of varnishes. There were over 30 samples of known composition and a large number of tests were made so that the average results quoted here give a reasonably accurate picture of the true relations. The values given under "oven dried" were obtained by baking for a short time (4-5 hours) at 95 deg. C. Continued baking would of course finally remove the greater portion of the low-resistance materials. The initial effect is to hasten their formation.

Inspection of these results shows that so far as the oils are concerned: (1) Linseed oil varnishes are the most acid. (2) Chinawood oil varnishes develop less acidity than the linseed oil varnishes. (3) With the same oil the acidity developed is greater, the greater the percentage of oil.

Research Department, H. C. P. WEBER.
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Results of Tests of Insulating Varnish Showing Acid Content That Forms Conducting Solutions With Water

MATERIAL	PER CENT	AVERAGE PERCENT ACID	
		AIR DRIED	OVEN DRIED
Linseed oil A	80	2.4	2.34
Linseed oil B	80	3.3	3.00
Linseed oil C	80	3.5	3.02
Restrainer D	80	2.5	2.8
Chinawood oil	80	1.5	1.8
Linseed oil	70	1.43	1.7
Linseed oil	50	0.88	1.68

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How to Put Odd Bits of Solder Into Usable Form

THE bits of solder which collect about the shop may be saved by melting them up and pouring them in some sort of mold. A simple and inexpensive mold which will give strips of solder of convenient size can be made in a moment from a piece of ordinary tongue-and-groove board, which has a groove about ¼ in. wide and ⅜ to ½ in. deep.

Clamp one or more of these boards, which may be three feet long or any convenient length, approximately level in a vise. The sides of the grooves should be greased or oiled in order to prevent the solder from sticking in the groove after it cools. Press a small piece of putty or clay on each end of the groove so as to form a sort of trough. This may then be filled with the molten solder poured out of a ladle. When cold the strips of solder can easily be removed from the groove by turning the board upside down and tapping one end on the bench top. The strips of solder may then be cut into convenient lengths with a pair of pliers.

Oakland, Calif. S. H. SAMUELS.

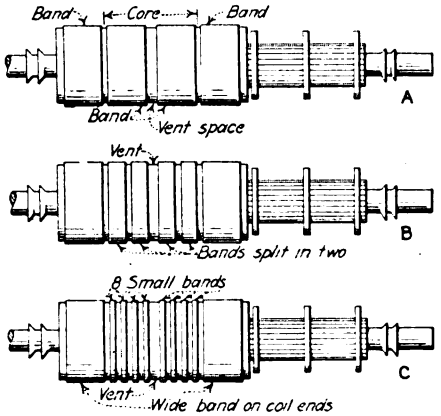
Eddy Currents Cause of Trouble with Armature Bands

SOME time ago I was called upon to repair an armature on which the bands had loosened up and the coils been thrown out of the slots, damaging the fields so that they, too, had to be rewound. This armature belonged to a 25-kw., 2-pole, 110-volt, turbine-generator which was used on a boat. After the armature was rewound it was banded with No. 12 steel banding wire, as shown in (A) of the illustration. We made two bands across the core, one on each side of the vent space, with the wide band on each end to hold the ends of the coils down. After the fields were rewound the generator was assembled and worked satisfactorily, although we had to excite the fields, as they had lost their residual magnetism.

Nothing more was heard of the job until the management of the boat line told us one day that the bands had come off again. Upon asking the engineer how the generator behaved he said that it had failed to build up and that he had run the turbine about 1,000 r.p.m. overspeed in trying to bring the voltage up to normal. Consequently, we blamed the high speed as the cause of the bands breaking.

The armature was again taken out and the coils retaped and put back into the slots. The fields had to be rewound again because the loose wire had ripped them to pieces. After the armature was finished it was banded as shown in (B), using more clips to insure against breaking the bands at high speed, and also splitting the bands in two, as shown. After running three days three of the bands came off again, leaving one on the core. In none of these instances had the end bands let loose.

After looking the remaining band over carefully we noticed that all of the solder was melted off the clips and wire; so we came to the conclusion that the bands were being heated up by eddy currents which were induced in them. The temperature was thus raised high enough to melt the half-and-half solder which had been used on all of these jobs.



Wide bands, as in A and B, heated up sufficiently to melt the solder and come off. When they were replaced with eight narrow bands, C, this trouble was eliminated.

As the coils had not been damaged this time, eight small bands of about five turns each were put on, as shown in (C), and the armature has operated satisfactorily ever since.

Milwaukee, Wis. E. KALEN.

Turning an Ice Machine Shaft Without Removing It

A LARGE brewery with three ice machines has a complete machine shop and some good mechanics, but this particular repair job required more equipment than they had and so a contract machine shop was called on for expert assistance. The split-type flywheel of this machine weighed six tons and was driven by a 1¼-in. key. The bolts at the hub had not been kept tight enough and the wheel had been working on the shaft for years, although the "engineer" had not noticed this because the wheel always went around and it did not shift endwise. Under the new regime, the "mysterious pound" in the machine had been located and found to be past correction; so the wheel was taken off.

Inspection showed that it would be best to get a new wheel and have it fit the shaft size after the latter was turned off approximately ⅛ in. below the original diameter of 10 in. The factory was given an order for a new wheel with the information that the shaft size would be forthcoming. It was decided to turn the shaft in place. A survey showed the shop man that a length of 16 in. was to be turned on a section over the pit and between an engine main bearing and the outboard bearing.

The plan that was adopted was to suspend a slide ahead of the shaft, in this section, and turn with a tool held in a carriage on that slide. In this case, the slide was the cross-rail from an 18-in. planer in the machine shop. This cross-rail was 30 in. long over all and the head with its toolpost provided means for moving and adjusting the tool both ways. A feed of 24 in. was possible, which was enough to get the desired position without interfering with the mode of suspension employed.

A pattern was made and two castings secured, which were placed on the two adjacent pillow blocks (from which the caps had been temporarily removed), after each casting had been drilled to pass over the two studs. At the outboard bearing, the cap was left off and the nuts screwed down tightly on the cast-iron bracket. At the main bearing, the casting was thinned down so the cap, when replaced, could be bolted to the proper fit on the shaft; afterwards, thin wedges were driven in to steady the bracket.

These brackets were made with a drop, or offset, that made a floor some distance below the horizontal center of the shaft upon which the cross rail was laid and to which it was bolted. This position was such that the tools would come the proper height for cutting the shaft.

The weight of the shaft was sufficient to keep it in place against the light cut, even if there had not been the one cap over it. The cross rail had been located on the side where the shaft ran "down" and against the top of the tool. For actual cutting, a speed of 20 r.p.m. was obtained by throttling the engine.

It took all of one day to do the actual turning of this shaft. The roughing cuts were used to check the parallelism of tool travel with the shaft's axis; before the final cut was taken, this had to be assured, because there could be no filing of the shaft to "touch up" when there was that keyway to bump the file every time around.

When completed, it was a first-class job and the cost was but a fraction of what it would have been had it been necessary to strip the machine and remove the shaft to a shop with lathes big enough to turn it.

Instead of sending the ice machine makers the size of the shaft in inches, a gage was sent to them, carefully protected in a box on its thousand-mile trip to Milwaukee, Wis. This gage was made of a piece of ½-in. by 2-in. black steel, forged half round, and fitted over the newly turned shaft—it was thought best to do the measuring this way and let the makers transfer the size as they chose.

In fitting this gage to the shaft, it was carefully filed out between the rounded points until it would pass over the shaft without feeling it touch, but so that it could be felt touching when a piece of newspaper was held on one side. For the final fit, the gage was immersed for 20 min. in a tub of water kept at 80 deg. F. by turning steam into it. The temperature at the time of fit and the method of gaging the feel of the fit were given to the builders. The wheel, when it was put in place, was so perfect a fit that the care spent in the work was fully justified.

DONALD A. HAMPSON.
Plant Superintendent.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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What Voltage Should Be Used for Testing the Insulation of Motors?

THE question of high-potential testing of motors and generators has always been a bone of contention. N. L. Rea, engineer in the Contract Service Department of the General Electric Company, in discussing this question in *Power*, points out that some operating engineers believe in periodic high-potential tests. In this connection he expressed his opinion as follows: They claim that they can thereby locate faults and make needed repairs without serious damage or delays. Others claim that every time the insulation on any equipment is overstrained part of its life is taken away. I am inclined to the latter belief. How much the life is reduced cannot, of course, be determined, but it is certain that a heavy strain does not do the insulation any good.

We ordinarily think of double voltage or higher when we speak of high-potential testing. This is all right for the new machines in the factory, which are clean and dry. It is altogether a different proposition with old machines. Many an old machine with years of satisfactory service ahead would have to be completely rewound after a standard A. I. E. E. high-potential test.

It is my belief that an old machine that has been thoroughly cleaned and varnished, should have a potential test to ground of the normal voltage. This would be about 25 per cent higher than the strains under ordinary operating conditions. This test can also be used on machines that are under suspicion, say after a heavy short-circuit on the generator cables or switches, a runaway, a bad shot in synchronizing or the like.

If a high-potential test is made, be sure the testing transformer is large enough. Many a man has fooled himself and others by using a 200-watt instrument transformer to give a big armature a high-potential test and multiplied the low-voltage reading by the name-plate ratio. If you want to kid yourself, this is a nice and safe way to do it. A large armature is a first-class condenser, and the charging current may require 20, 30, or even 50 kva.

When in doubt it is safer to get advice from the manufacturers of the machines in question. They are always glad to give advice and suggestions.

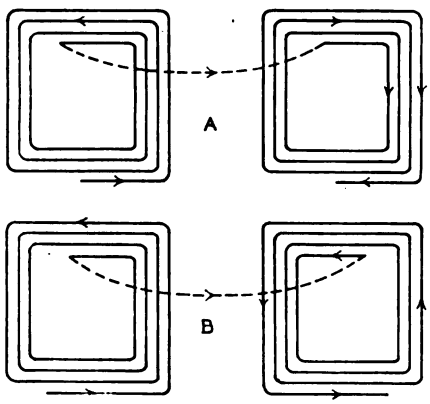
The use of a spark gap to measure the voltage should be avoided if possible. It's a good idea to use a spark gap as a safety valve, but it is better to use a small transformer across the high side of the testing transformer and read the voltage from the low side of this small transformer. This discharge of the spark gap may set up oscillation and cause a higher voltage than desired or indicated.

The use of kenotrons to rectify alternating current to direct current gives a means of high-potential testing with a very small amount of electrical energy.

This method, however, is in an experimental stage, and alternating current will probably be available and used in the majority of cases for some time to come.

Improper Connection of Motor Field Winding

A STANDARD electric railway car motor had been temporarily applied to a hoisting job and on being retired from this duty it was overhauled on account of being oil-soaked. After it was overhauled it looked good but it would not run. The usual tests were applied for open-circuits, grounds and short-circuits; none could be found.



The coils were composed of two sections which were connected so that they bucked each other, A. The correct connection is at B.

The armature was then removed from the frame, the frame closed, current passed through the field coils and the polepieces tested for polarity with a compass. The compass gave indications no one could understand. On trying the polepieces with an iron bolt, the pull on the bolt was suspiciously weak although full-load current was being passed through the field coils. This suggested that all of the coils were short-circuited —which was an unlikely condition.

The machine was sent to a repair shop to be investigated and its action related to the investigator. Full-load current was passed through the field circuit and the voltage drop taken on each coil. All of the drops were the same and about what was to be expected in value. As this eliminated the short-circuit idea, all of the insulation was ripped off the coils in order to inspect them.

The inspection disclosed the trouble. Each coil was composed of two similar sections of flat copper insulated with asbestos. Section (2) was to be placed on top of section (1), the inside ends then being clipped together. In the illustration (A) shows how the sections were connected, the two sections being shown alongside each other. By following the arrow heads it will be seen that current entering through either outside lead will circulate around the two sections in opposite directions. On turning the second section over before laying it upon the first section is produced the condition indicated in (B). It will be seen that current entering the free end of either section, will circulate around both in the same direction.

Brooklyn, N. Y. J. A. HORTON.

Changing Two-Phase Motor for Three-Phase Operation

ONE of the small townships in Michigan recently changed the generating equipment from two phase to three phase and in changing over motors in local plants to meet the new line conditions some interesting situations were encountered.

One case involved a 2-hp., 220-volt, two-phase, 5-amp., 1,800-r.p.m., four-pole, sixty-cycle motor that had thirty-two slots and coils, each coil consisting of forty-two turns of one No. 18 d.c.c. wire, pitch 1-and-8, connected two-parallel.

Now, thirty-two coils will give a balanced, equal coil grouping for four poles, two phase, as there are sixteen coils per phase, or $32 \div (2 \times 4) = 4$ coils in series per pole-phase group; but for three phase four poles, the grouping will be unequal and the coils per phase will be unequal, as $32 \div 3 = 11$ plus 11 plus 10 coils per phase, which will not do for a stator winding.

Then in order to obtain an equal number of coils per phase, two coils will have to be killed or left out ,making a total of thirty coils, which will necessitate calculating the three-phase winding to compensate for the lost turns.

The series-delta, three-phase line voltage, using the same turns per coil, would be $[(2 \times 2 \times 220) \div 3] \times 1.06 =$ 310 volts, but a series-star connection is preferable in this case, as there will be unequal grouping and two coils left out. Then the series-star line voltage would be $310 \times 1.73 = 536$ volts. To develop 536 volts, there would be $(32 \times 42) \div 3 = 448$ turns per phase, and for a three-phase, 220-volt, series-star connection there would be required $220 \div 536 = X \div 448$ turns per phase; or $(220 \times 448) \div 536 = 183$ turns, and with ten coils per phase there would be $183 \div 10 = 18.3$ or eighteen turns per coil. By figuring the turns per phase as above, the turns lost in the two coils are compensated for.

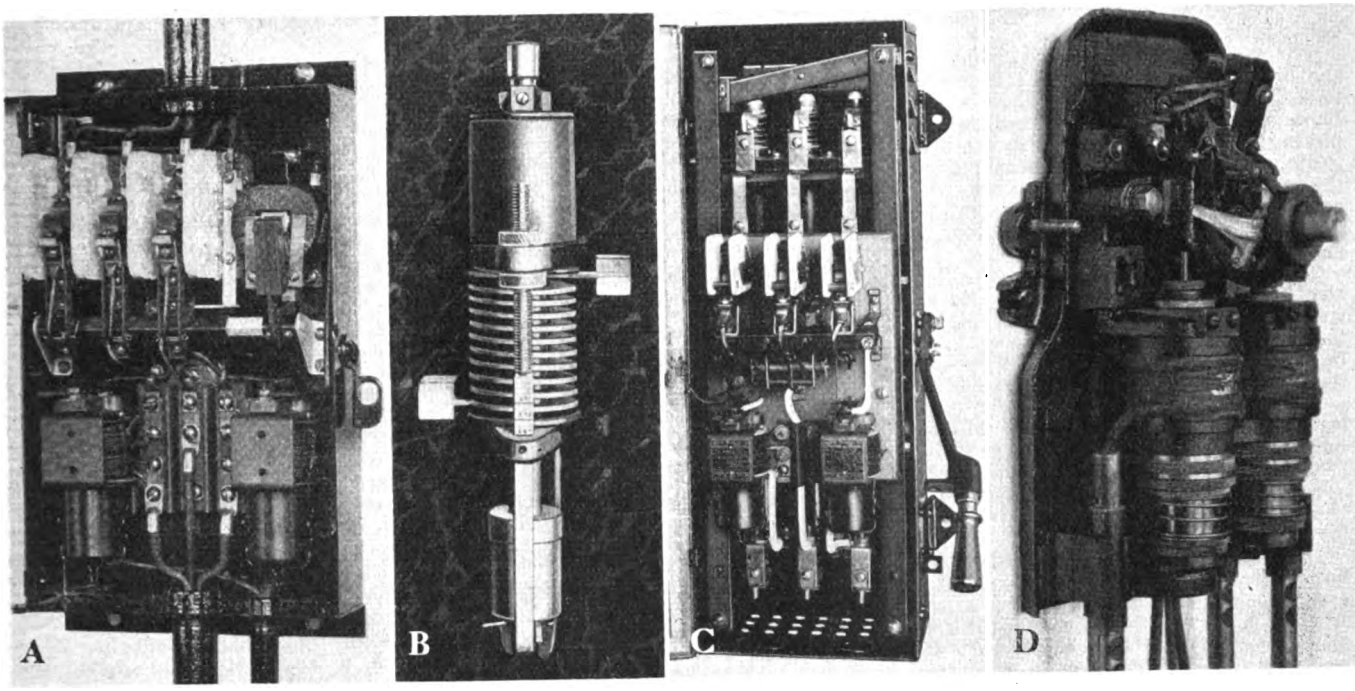
With 5 amp. per terminal and a two-parallel connection the current per coil was 2½ amp. One No. 18 wire has an area of 1,624 circ. mil, and at 2½ amp. there were $1,624 \div 2.5 = 650$ circ. mil, per amp. The three-phase, 220-volt, 2-hp. current rating would be approximately 6 amp. and with a series-star connection this would also be the current per coil and with 650 circ. mil per amp. there would be required $650 \times 6 = 3,900$ circ. mil. The wire size closest to this is No. 14, with 4,106 circ. mil. Trying a slot full of thirty-six No. 14 silk-covered-and-enameled wires it was found that there was enough room for this winding.

The three-phase winding then consisted of thirty coils, each coil containing eighteen turns of one No. 14 silk-covered-and-enameled wire, pitch 1-and-8, connected series-star, ten coils per phase with six groups of two coils and six groups of three coils arranged as follows: (2-3-2) (3-2-2) (3-3-2) (3-2-3).

After winding and testing the motor ran satisfactorily and was evenly balanced in all three phases.

Wilkinsburg, Pa. A. C. ROE.

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What Happens During Single Phasing

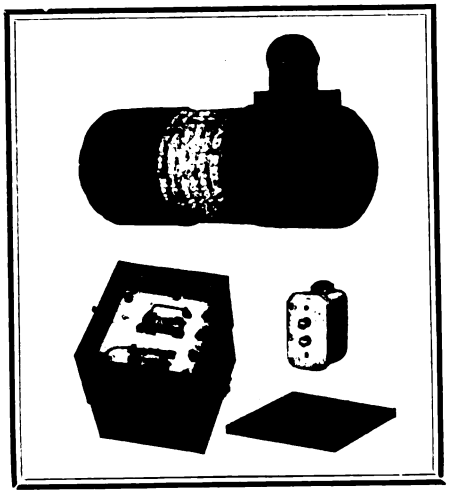
(*Continued from page 187*)

No-voltage releases do not protect against single-phase operation. For even though one wire is opened, the motor itself will maintain voltage on that wire, so that failure of *voltage* of any phase does not occur if a motor is connected to it. Instances are on record where one wire of a factory supply has been interrupted at the source, and the motors of the plant kept that wire energized so that there was always three-phase power around the plant as long as some motors were running. Motors could be started three-phase; all three voltages were present, although badly unbalanced; and no one knew that one phase was open until the motors began to burn out. If all the motors in the plant had been shut down at the same time, the third wire would have lost its potential and the motors would not have started again, but as long as some motors were running, they acted as phase converters and supplied the idle wire.

EDITOR'S NOTE:—Special acknowledgment is made to the following companies for their kindness in furnishing information and some of the illustrations accompanying this article: The Automatic Reclosing Circuit Breaker Co., Columbus, Ohio; Allen-Bradley Company, Milwaukee, Wis.; Condit Electrical Manufacturing Company, South Boston, Mass.; The Cutler-Hammer Manufacturing Co., Milwaukee, Wis.; The Electric Controller & Manufacturing Co., Cleveland, Ohio; Federal Electric Company, Chicago, Ill.; General Electric Company, Schenectady, N. Y.; Industrial Controller Company, Milwaukee, Wis.; Monitor Controller Co., Baltimore, Md.; The Rowan Controller Co., Baltimore, Md.; Sundh Electric Co., Inc., Newark, N. J.; Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Time element overload relays are another form of protection used to prevent single phasing.

Such relays may be set to trip at full-load, motor line current and yet take care of momentary overloads without tripping. At *A* is shown the across-the-line starter made by the Industrial Controller Company of Milwaukee, Wis. The inverse time element relays are located in the lower left- and lower right-hand corners of the starter. The inverse-time element is secured by means of oil dashpots. At *B* is shown the time element relay used by the Monitor Controller Company of Baltimore, Md., in its larger starters. The time element in this relay is also secured by means of an oil dashpot. *C* is a semi-automatic resistance starter made by the Allen-Bradley Company of Milwaukee, Wis. The time element relays used for overload and lost-phase protection are shown at the lower left- and lower right-hand corners of the compensator. An oil dashpot is also used in this relay to give the time element. *D* shows the time element relay used by the Electric Controller & Mfg. Company of Cleveland, Ohio, in their larger starters. This relay has two coils and two dashpots; one for each phase.



Single-phase and overload protection device made by the Condit Electrical Mfg. Company of South Boston, Mass.

In the lower illustration is shown a motor starter which is arranged for thermal relays. The thermal relay, shown in the upper illustration, has a thermal element which is acted upon by the motor line current and in case of abnormal load will break a control contact, thus stopping the motor.

Short-Center Belt Drives

(*Continued from page 172*)

per inch of belt width should be between 32½ and 84½ lb. when running at the calculated belt speed of 4,000 ft. per min. for this drive. We have a single-stage compressor doing intermittent duty; so we may take a value about halfway between these two extremes as explained in note 4 of Table I. We will choose a value of 50 lb. per in. of belt width. Our driving pulley diameter of 13½ in. is about the minimum recommended for double-ply belting; hence we could use either single or double belting with about equal advantage.

If we use standard double-ply belting, the belt width will be equal to (horsepower×33,000)÷(belt speed×effective tension per in. width)=(7.2×33,000)÷(4,010×50)=1.2 in.

This is a ridiculously narrow belt for double-ply belting. We will use a single-ply belt of double the width worked at 25 lb. effective tension per inch of width. Since a 2.4 in. belt is an odd size, we will use one 2½-in. wide. Our effective pull will be equal to the belt width times the effective pull equals 2.4×25=60 lb. This gives an effective tension per inch of belt width of 24 lb.

Referring to Table I and notes 8, 9, 10 and 11 under it, we find that for a belt speed of 4,000 ft. per min. the slack-side tension should be somewhere between 60 and 30 per cent of the effective tension. Since this is a single-stage compressor and will run intermittently (see note 9), we will choose a value of 59×1.5=68 per cent. Hence our static or slack-side tension will be 68 per cent of the effective tension or

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0.68×60=41 lb., or 16.5 lb. per in. of belt width.

We will now make our layout as shown in Fig. 6. A_1B_1 will be equal to C_1D_1 and they are both equal to 41 lb. as we have just determined. Completing the graph as shown in the diagram, we find that O_2E_1 measured to the same scale as the other lines, will equal 58.75 lb. This is the weight of the idler and that part of the fittings supported thereby.

The rods *RO* are made of cold-rolled steel, or in this case pipe would do as well. Suppose a computation places the total weight of the two rods at 7.5 lb. The shaft for the idler pulley and the connecting fittings will weigh 5 lb.

The weight other than the idler pulley to be supported by the belt will be half the weight of the rods, that is, 3.75 lb. plus the weight of the shaft and fittings (5 lb.) or, a total of 8.75 lb. Hence the net weight of the idler pulley would be 58.75–8.75=50 lb.

It would be best to make this idler pulley about the same diameter as the motor pulley, but since we are using single belt on a pulley large enough for double belt, it will be satisfactory to have the idler 10 in. or 12 in. in diameter or even smaller if a suitable pattern is in stock.

Suppose that instead of the direct-current motor used in the previous example we wish to use a squirrel-cage induction motor and start it across the line so as to use a cheap form of automatic starter for starting and stopping the compressor in maintaining an approximately constant air pressure. Let us see how this will affect our layout.

Our load is 7.2 hp. We must use either a 5-hp. or 7½-hp. motor, since standard motors are not available in intermediate sizes. A normally-rated 5-hp. motor (40-deg. temp. rise) would scarcely carry this load unless we could be certain that conditions would be such that the motor would operate only a very few minutes in each hour. Even then if we decided to use a 5-hp. motor, we would be obliged to use a thermal relay, or some similar device to protect the motor, if due to a leak in the piping, the compressor were called upon to operate more or less continuously in order to keep the pressure up in the receiver. We will use a standard 7½-hp. motor. We know that it will stop and start very many times per day.

First we make a complete computation for running conditions which will be identical with that given in the previous example. Next, we must make a complete computation for starting conditions. The manufacturer informs us that his motor will exert a breakdown or maximum running torque equal to 250 per cent of full-load torque. It is necessary when obtaining this information from the manufacturer, to make it plain that you desire not the minimum starting torque for the type of motor, but the actual starting torque for the particular size and speed of motor in question. If the motor is likely to be operated at higher than nameplate voltage, it is necessary to increase the manufacturer's figure for starting torque by 2 per cent for each 1 per cent of overvoltage under which the motor is likely to start. This torque will be exerted while the motor is starting as it passes through about 75 per cent of full-load speed, that is, at a belt speed of approximately 3,000 ft. per minute.

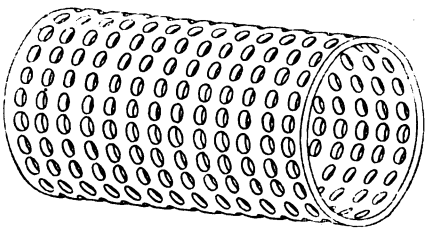


Fig. 7—Method of lubricating the idler pulley.

If a tube, drilled full of holes as shown, is interposed between the idler bore and the shaft, the holes will soon fill with grease from the grease cup located as shown in Fig. 1, and will make it necessary to lubricate the idler only at long intervals.

From our previous calculation we found that the effective pull was 60 lb.; hence for this design we must make a design for 250 per cent of 60 lb. which equals 150 lb. effective pull at 3,000 ft. per min.

From Table I, and notes 2, 3 and 4 following it, we decide that 60 lb. will be a reasonably effective pull per inch width of standard double-ply belt. So narrow a double belt as we are considering would probably be light double-ply rather than standard double-ply. This, according to Table I, would call for a stress of 75 per cent×60=45 lb. per inch of width.

Our motor pulley diameter will allow us to use either single- or double-ply belt.

For standard double-ply belting, the belt width would be equal to (horsepower×33,000)÷(belt speed×effective tension per inch of belt width). Since the motor will exert a maximum running torque of 250 per cent, the horsepower used will be 7.5×2.5=18.75. Reference to Table I will show that with light double-ply belt we should use 75 per cent of the effective tension per inch of belt width that we would use for a standard, double-ply belt and 50 per cent of the effective tension for a single-ply belt. Hence, substituting these values in the formula we find that the width for a light double-ply belt will be (18.75×33,000)÷(3,000×60×0.75)=4.6 in. For a single-ply belt, the width will be equal to (18.75×33,000)÷(3,000 × 60 × 0.50) = 6.87 in. For a standard double-ply belt, the width will be (18.75×33,000)÷(3,000×60×1.0)=3.44 in. It is likely that the width of face on our compressor pulley is less than 7 in. If this is the case, there is no alternative but to use a 4.5-in. light double belt or, if we choose, a 3.5-in. standard double belt.

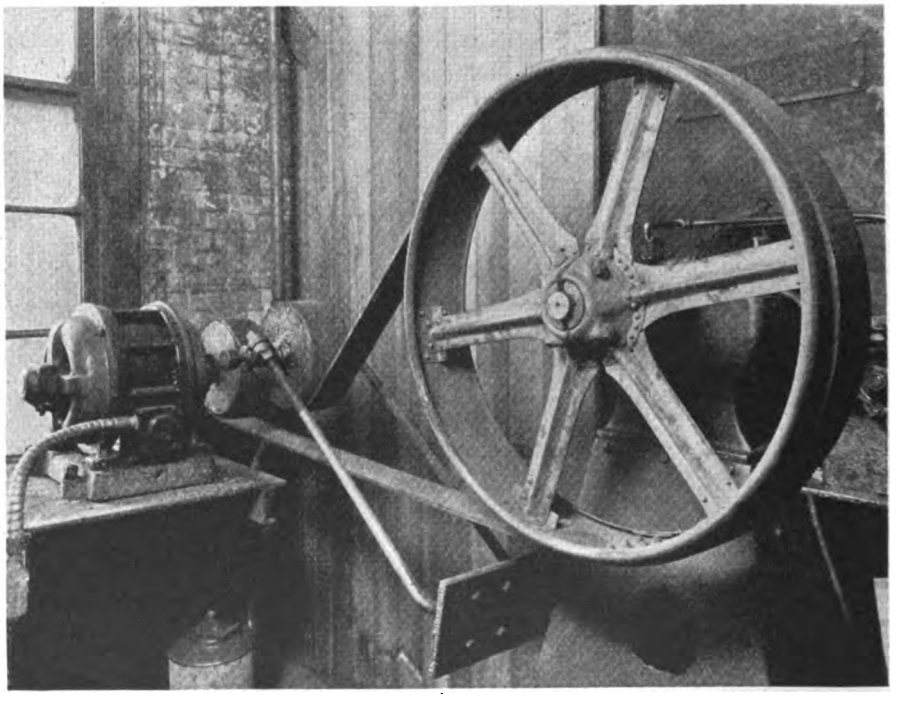
As referred to in notes 6, 7 and 8 of Table I, we should use column C_1 of Table I in determining the slack-side tension. Referring to this column, we find that the slack-side tension for a belt speed of 4,000 ft. per min. should be 25 per cent of the effective pull. Our effective pull we have just found to be 150 lb. Hence our slack-side tension will be 0.25×150=37.5 lb., say 38 lb.

Now for our layout. We can use the same layout as before in Fig. 6. We must, however, use a different scale in measuring it—a scale of 38/33 times that used previously. Completing the graph we find that the necessary weight of idler, shaft fittings and half the rods will be 54 lb. The net weight of the pulley necessary would then be 45.25 lb.

In this case we see that both belt size and pulley weight must be determined from starting conditions. If an example had been selected with ex-

Fig. 8—Short-center drives are just as effective on small units as on the larger drives.

A 3½-hp., two-speed, 600-1200-r.p.m., squirrel-cage induction motor drives the foundry fan shown at the right of the illustration through a 4-in. belt. Both the idler and motor pulleys are 12 in. in diameter, while the driven pulley is 36 in. in diameter. To secure the most effective weight of the idler, which would give the proper belt tension for the load carried and still not unnecessarily overload the belt, it was necessary to use a wooden pulley for the idler.



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tremely high belt speed, we would have found that the size of belt was determined by the starting conditions and the pulley weight by the running conditions.

A simple and reliable method of lubricating the idler pulley is essential. Grease is generally used for this purpose. An excellent method is to drill the idler shaft, put a grease cup on the end as shown in Fig. 1, and drill several holes, say three, at three points along the shaft. If a tube drilled full of holes, as shown in Fig. 7 is interposed between the idler bore and the shaft, the holes will soon fill with grease, and will make it necessary to lubricate the idler only at long intervals.

On small fan drives and the like where the loads are less than 50 hp., the required weight of idler frequently figures out so low that a cast-iron pulley of suitable diameter and width cannot be designed. In such a case a paper or wood pulley as shown in Fig. 8, will generally solve the problem at lower cost even than a cast-iron pulley. *Order it without keyway* for such pulleys are ordinarily stocked with keyways, and the keyway offers a path for the grease to work out without doing its duty.

Do not make idler pulleys too small. A small idler pulley will, it is true, allow a slight increase in arc of belt contact, but the sharp reverse bend is hard on the belt. The idler pulley should be at least as large as the driving pulley. Where the driving pulley is near the lower limit for thickness of belt, the idler pulley may well be 10 to 20 per cent larger, even at some sacrifice of the arc of contact of the belt on the driving pulley.

I need hardly mention that in making the original layout to determine relative location of motor pulley, angle of hinge rods, size of idler pulley, and the like, it is well to sketch in the idler pulley at the position which it will occupy after taking up on the belt. If the idler pulley will strike the driving or driven pulley in this position, do not let it go with the idea that the operator can adjust the reach rod length as the belt stretches. Idler pulleys jump from time to time as the motor starts, especially when the starter is out of order and the electrician starts the motor on the line "just once" to avoid an objectionable delay. Then, if a belt lacing comes just right, or if the idler pulley interferes by only ⅛ in. or so, or if several other "ifs" happen, something will bend or break, generally the motor shaft. Such a layout may usually be made entirely satisfactory by moving the motor back a few inches, or changing the inclination of the hinge rods, or both.

If you change the inclination of the hinge rods after you have determined the weight of the required pulley, make a new layout, and determine that weight once more. Any change in the inclination of the hinge rods will change the required weight as will be evident from a consideration of the graphic layout.

Whenever possible use a glued or cemented joint in the belt. A laced belt has a way of slipping as the laces pass the driving pulley.

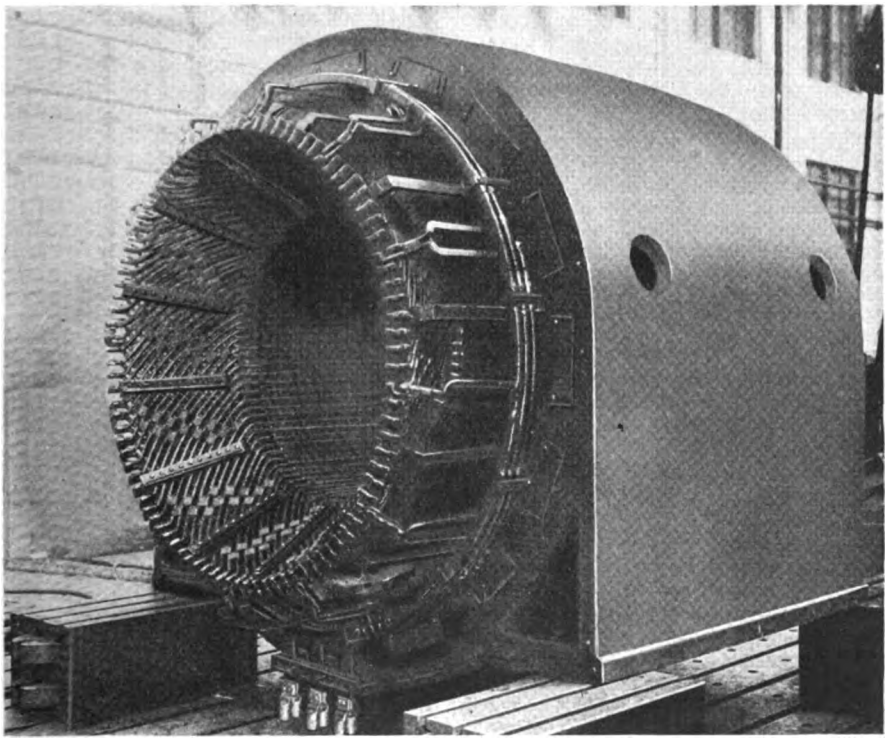


Fig. 9—The method of tying the end turns together can be seen in this illustration.
This is in addition to the method of bracing described in Fig. 1. This machine is much smaller than those shown in Figs. 1 and 4.

Turbo-Generator Windings

(*Continued from page 181*)

In this winding, there are six pole-phase groups, each group having six coils. A front pitch of 1-and-13 is used, and a back pitch of 1-and-14 is required. Let the A phase start with the terminal T_1 which is connected to the bottom conductor in slot *1*. In this diagram, the bottom conductor in a slot is shown by a short line while the top conductor in a slot is shown by a long line. The rear end of the bottom conductor in slot *1* is connected to the rear end of the top conductor in slot *14*. The front end of the top conductor in slot *14* is connected to the front end of the bottom conductor in slot *2*. The winding then continues through this pole-phase group through slots *15*, *3*, *16*, *4*, *17*, *5*, *18*, *6* and *19*. This pole-phase group ends at the top conductor in slot *19*; the front end of this conductor is then connected by means of the jumper *J* to the ring *P*, which is connected by means of the jumper *L* to the front end of the top conductor in slot *1*. This starts the second pole-phase group for the A phase. The second pole-phase group ends in the bottom conductor in slot *19*, which is connected by means of the jumper *D* to the star ring *S*. The remaining two phases are connected in a manner similar to the first.

The diagram shown in Fig. 6 is the same as would be given to the winder in the shop. If this machine were to be stripped, the coils reinsulated and the old connection used again, the rings and jumpers should be marked as shown by the letters, for otherwise it would be difficult to fit together the 17 different-sized connections and rings. By marking the slots, leads, and end connectors from the coils to the rings, there will be no time lost in sorting out the various end connectors and trying to find where they fit.

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Practical Books
For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Electrical Drafting and Design—By Calvin C. Bishop. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City, 161 pages, price $2.00.

In the preface of this book the author states that it was his purpose to bridge the gap between the usual course in mechanical drafting as taught in technical and vocational schools and the work a young man is required to do in the office of an engineer, a contractor or a power company. Numerous examples of wiring layouts are presented, with data forms giving dimensions of apparatus and other information needed without going to the trouble of obtaining many catalogs and data sheets for this purpose. The chapter headings are as follows: General instructions for mechanical and electrical drafting; electrical symbols and their use; generator and feeder panel; three-phase panel; outdoor substation; laying out wiring; residence wiring; artificial illumination; and tables and charts.

* * * *

Practical Mathematical Analysis—By H. Von Sanden. Published by E. P. Dutton & Co., New York City, 194 pages, price $4.50.

This book is written for those who have a thorough groundwork in mathematics and presents mathematical methods by which the solution of any given problem may be evaluated in a numerical form. The following subjects are treated: The slide rule; the calculating machine; rational integral functions and their extrapolation; numerical differentiation and integration; mechanical quadrature; integration and differentiation by graphics; analytical approximation to empirical functions; solution of equations, linear, transcendental and non-linear; integration, graphical and numerical, or ordinary differential equations of the first, second, and higher orders.

* * * *

Eye Hazards in Industrial Occupations—By Louis Resnick and Lewis H. Carris. Published by the National Committee for the Prevention of Blindness, Inc., 130 East Twenty-Second Street, New York City, 250 pages, 60 illustrations. Price, paper bound with linen backing $1.50; fabrikoid bound, $2.50.

This book is a compilation of a large number of methods and applications of various devices for the protection of the eye from injuries by flying objects, chemicals and a large number of other more uncommon hazards. A chapter is devoted to a discussion of the necessity, value and problems incidental to industrial lighting. Some of the topics discussed in the various chapters are: Nature and causes of eye injuries; eliminating eye hazards; industrial accidents and means for their prevention, first aid treatment for eye injuries; correction of defective vision; diseases affecting the eye; industrial lighting; education as to safety; the safety movement and its effect on the eye hazards in industrial occupations.

An appendix gives industrial poisons presenting hazards to the eye, and a goggle code of the American Steel and Wire Co., which shows all the occupations where goggles are compulsory or desirable in various departments.

* * * *

Substation Operation—By Edwin Kurtz. Published by the McGraw-Hill Book Co., 370 Seventh Ave., New York City, 252 pages, price $2.50.

This book has been written to help the practical operator and his assistants to obtain a knowledge of the principles as well as the methods of substation operation. It deals with substation layout and wiring and gives details of all the equipment that is used in the modern power substation. Three chapters, which occupy practically one-half the book, will be found very useful for the practical man. These chapters give operating procedure in connection with substation work, instructions on hunting troubles and correcting them, together with details on accident prevention. Illustrations show views in different types of substations and the procedure recorded follows the best practice of operating companies. For those who are required to train substation operators and are responsible for inspection and maintenance, this book will be a useful guide and handy reference.

* * * *

Industrial Electricity — Part 1 — By Chester L. Dawes. Published by the McGraw-Hill Book Co., 370 Seventh Ave., New York City, 363 pages, price $2.25.

This book has been written as a textbook for use in connection with elementary electrical engineering, both in high schools and schools preparatory for college work. The first volume is devoted to direct current, while the second volume, under preparation, will deal with alternating current. Throughout the text the author explains in simple language the principles underlying electrical engineering and electrical equipment and gives a bird's-eye view of electrical problems to those who are beginning a study of the subject. While the text deals with underlying principles of circuits and machine operation, illustrated problems and details of equipment are given in such practical form that the student can apply the fundamental discussions to practical work. The subjects discussed in this book are: Magnets and magnetism; electro-magnetism; resistance; Ohm's law and the electric circuit; battery electromotive forces; primary and secondary batteries; storage batteries; electrical instruments and electrical measurements; the magnetic circuit; electrostatics; the generator; generator characteristics; the motor; and losses in efficiency and operation.

* * * *

Practical Radio—By James A. Moyer and John F. Wostrel. Published by McGraw-Hill Book Co., 370 Seventh Avenue, New York City, 244 pages, illustrated, price $1.75.

This book describes practically all of the successful circuits that are now used in radio receivers. It gives details on their construction and operation and how to test and repair them. Many wiring diagrams are used and information is given covering the construction and features of the essential parts of a radio circuit. The subjects covered are as follows: The antenna, radio electricity explained, telephone receivers and crystal receiving sets, vacuum tube receiving sets, sources of electricity for vacuum tubes, audio-frequency amplification, radio-frequency amplification, selection, operation and care of radio receiving sets, radio telephone and telegraph transmission, construction and testing of receiving instruments, common troubles and their remedies, the future of radio.

* * * *

American Society of Heating and Ventilating Engineers Guide—Published by the American Society of Heating and Ventilating Engineers, 29 W. 39th St., New York City, 445 pages, price $3.00.

This book contains reference and design data useful in the planning and construction of modern heating and ventilation installations. Material has been taken largely from the Society's Transactions, investigations by its research laboratory and the practice of its members. With this information is presented a catalog and reference-data section containing essential and reliable facts concerning heating and ventilating equipment. The book contains a mass of tabulated information, diagrams and charts. The heating section includes 161 pages and the ventilating section, 63 pages. This guide will be found very useful by those who have to lay out and install heating and ventilating systems.

* * * *

Engineering in American Industry—By Conrad Newton Lauer. Published by McGraw-Hill Book Co., 370 Seventh Ave., New York City, 94 pages, price $2.50.

This book is published in 9 in. by 12 in. size and for the most part embodies material delivered in lectures at Princeton University under the Cyrus Fogg Bracket lectureship in applied engineering technology. The author reviews the growth and development of manufacturing in the United States and the contributions which engineering has made. The subject matter is profusely illustrated with halftones, line diagrams, maps, curves, and charts. The maps, curves and charts are presented in large size so that the information given can be easily interpreted. Captions under each diagram explain in detail the features which these charts and diagrams are intended to illustrate. There are 61 diagrams and curves presenting statistical information on the material resources and industrial activities in the United States. For those who have occasion to use statistical information of this sort the book will be invaluable.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Hart Manufacturing Company, Hartford, Conn.—A 64-page booklet, pocket size, entitled "Diamond H Remote Control Switches," describes the various types of multi-circuit, no-voltage release and tank switches as well as relays and solenoid devices which simplify the control, effect a saving in the first cost of installation and current consumption, and also provide control at various points from a distance without making it necessary to bring the service wires to these points.

Flohr Safety Appliance Manufacturing Company, Buffalo, N. Y.—A folder illustrates and describes the construction and advantages of the Flohr superior saw guards and superior jointer guard for use on woodworking machinery.

Albert and J. M. Anderson Manufacturing Company, 289-305 A Street, Boston, Mass.—Bulletin 35 is a complete catalog of Anderson's "Charging Plugs and Receptacles" for charging storage batteries on electric vehicles, trucks and railway cars.

The Glow Electric Company, 219-21 Walnut Street, Cincinnati, Ohio—A 12-page stock price list gives the new and rebuilt motors and generators as well as other electrical apparatus held in stock by this company.

Rochester Electric Products Corporation, 695 Driving Park Avenue, Rochester, N. Y.—Bulletin 5 describes the Price-Rochester constant potential battery charging system.

Wagner Electric Corporation, St. Louis, Mo.—Bulletin 142 describes the Wagner split-phase, induction motors of the BB type which are built in ratings of 1/6, 1/4, 1/3 and 1/2 hp. for 110 or 220 volts.

Electric Machinery Manufacturing Company, Minneapolis, Minn.—Bulletin 861, entitled, "Synchronous Motors for Pumping," describes and illustrates a number of synchronous motor applications to centrifugal pumping and gives considerable engineering data regarding such applications.

L. B. Allen Company, Inc., 453 North Lincoln Street, Chicago, Ill.—A series of folders describes the Allen non-acid soldering salts, paste, liquids, alumi-flux, alumi-solder and alumi-weld flux, as well as a commutator lubricant. The Allen combination gas-air blow torch soldering and branding tools for use in connection with gas or gasoline are also described, together with the various tips used for different work.

The Yale and Towne Manufacturing Company, Stamford, Conn.—A folder describes the new Yale ball bearing chain block which is made in 11 sizes ranging from ¼ to 20 tons capacity.

Edward T. Moore, 500 Cahill Building, Syracuse, N. Y.—A folder describes the Moore electric power regulator which limits the peak load upon which current cost is based. With this limitation power is billed only for the amount of current which represents a fair average of the daily power consumption instead of on the basis of peak demand.

The Baker R. & L. Company, Cleveland, Ohio—Catalog 29 covers in 52 pages the line of Baker industrial tractors and trucks and discusses the problem of electric material handling and the equipment suitable for it.

Jannette Manufacturing Company, 356-358 West Monroe Street, Chicago, Ill.—A folder entitled, "He Wouldn't Believe It," gives several of the advantages of the Jannette special fractional horsepower motors for use under unusual service conditions.

Philadelphia Gear Works, 1124 Vine Street, Philadelphia, Pa.—A catalog shows the variety of gears manufactured by this company and in addition gives a number of important points to consider in the use of gearing.

Lewellen Manufacturing Company, Columbus, Ind.—A folder entitled, "Put It To Any Test," shows several Lewellen installations under severe service conditions.

The Falk Corporation, Milwaukee, Wis.—Bulletin 35 describes the Falk-Bibby flexible couplings which are made in sizes ranging from 1/3 to 20,000 hp. at 100 r.p.m. This bulletin illustrates the construction, the various features in connection with the operation and gives suggestions on the selection of the proper size and rating as well as special instructions showing how the size of coupling should be determined.

General Electric Company, Schenectady, N. Y.—Bulletin 47640.2 describes and gives applications of the induction, time, over-current relays, Types IA-201, IA-202, IA-205 and IA-206. Details of construction, lists of available range ratings and principles of operation are covered together with other general information. The bulletin is illustrated by photographs, charts and diagrams.

The Roeper Crane and Hoist Works, Reading, Pa.—Catalog 50, containing 16 pages, describes and illustrates the various types of Roeper electric hoists and shows a few of the many applications which can be made of them.

Ingersoll-Rand Company, 11 Broadway, New York City—A circular describes the new air motor hoist which is made in five sizes, with capacities from 500 to 10,000 lb., and also illustrates a number of their applications.

Century Electric Company, 1827 Pine Street, St. Louis, Mo.—A folder entitled, "An Announcement of Extraordinary Importance to Every User of Small Motors," describes the Century wool-yarn system of lubrication for fractional horsepower motors. This motor lubrication was designed for motors in continuous service over long periods of time without re-oiling.

Paul W. Koch and Company, 23 South Wells Street, Chicago, Ill.—A small circular entitled, "The Hole Story," describes the Jiffy adjustable cutter which may be used for cutting holes from ¾ in. to 6 in. in diameter in metal of any gage and up to ¾ in. thickness.

The Service Caster and Truck Company, Albion, Mich.—A 24-page catalog describes this company's line of swivel and rigid casters for trucks. These are provided with ball, Hyatt, or Timken bearings and may be supplied with rubber, fiber or other special treads.

Stephens-Adamson Manufacturing Company, Aurora, Ill.—A booklet entitled, "The Latest Developments in the Design of S-A Unit Carriers," describes the application of high-pressure lubrication and all-steel ball bearings to the carrier roll for belt conveyors.

Crouse-Hinds Company, Syracuse, N. Y.—Folder 13 describes the connectors of the CG series which are made to take rigid or flexible conduit, armored cable or condulets.

General Electric Company, Schenectady, N. Y.—Circular 66028 describes the special temperature indicating panel for generators and motors and the equipment operating on direct-current circuits to indicate at the switchboard the temperature of the various portions of the windings of electrical machinery during operation.

Buffalo Forge Company, Buffalo, N. Y.—A comprehensive review of the use of electric fans for blowing, exhausting, ventilating, cooling and drying is contained in a 16-page illustrated booklet. This covers direct connected units driving small disk or propeller fans, used for ventilating, stoker units, pressure blowers, mill exhausters and electric forge blowers.

Cleveland Armature Works, Inc., 4732-4736 St. Clair Avenue, Cleveland, Ohio—Catalog 315 covers the individual motor driven electric grinders, buffers and polishers, which are made in medium and heavy-duty types.

G. & W. Electric Specialty Company, 7440-42 South Chicago Avenue, Chicago, Ill.—A 16-page booklet, Bulletin 24, illustrates and describes the various G. & W. potheads for protection of cable ends and gives instructions for installing potheads, with other useful information.

Pyott Foundry Company, 28 North Sangamon Street, Chicago, Ill.—A circular describes the Pyott hangers and hanger boxes for duplex, ring or ball bearing lubrication.

The Nichols Lintern Company, 7960 Lorain Avenue, Cleveland, Ohio—A folder describes the Lintern electro magnetic sander for crane runways which is operated by a foot button located in the cab. This folder also il-

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lustrates the various types of lightweight signal lanterns for industrial applications.

Smooth-On Manufacturing Company, 570-574 Communipaw Avenue, Jersey City, N. J.—"Smooth-On Handbook" in its twentieth edition is a pocket-size book of 136 pages, which contains descriptions of the various types of Smooth-On cement, shows the purpose of each and in addition, shows by illustrations and descriptions how a number of repairs have been made in industrial plants through the use of Smooth-On. Some applications of Smooth-On floor hardeners and special paints are also included.

Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.—Circular 1579-C entitled "Micarta Gears and Pinions" gives the advantages claimed for Micarta and similar non-metallic materials, describes the methods of machining and illustrates cutting tools, gives the physical and mechanical properties and methods for computing the horsepower rating. Two pages of gear data show these computations in tabular form over a wide range.

The Panelyte Company, Trenton, N. J.—Booklet entitled "Panelyte Electrical Insulation" describes the composition and electrical and mechanical characteristics of Panelyte, a hard fibre, dielectric substance which is claimed to be easily drilled, tapped, sawed and polished, although it is not brittle, and is much lighter than stone and similar materials used for switch backing and like purposes.

Shepard Electric Crane and Hoist Company, Montour Falls, N. Y.—A 60-page catalog on, "Floor Operated Electric Hoists," gives a complete discussion of all of the Shepard floor-operated electric equipment This material is arranged in groups with, first, a general description, and then an installation view, which is followed by a portrait view of the hoist. On the next page are given data and price lists and on the page following drawings and dimensions. All the special and extra equipment, which is applicable to all types of machines and must be referred to constantly, is given in the center of the book on green printed stock. Floor-operated equipment is made without trolley (lug or hook suspension), with geared trolley and with motor-driven trolley.

Trico Fuse Manufacturing Company, Milwaukee, Wis.—A folder describes the new line of Trico "Kantark" non-renewable fuses, which are made in all standard sizes up to 600 amp. rating and are fully approved for both 250 and 600 volts.

Steel City Electric Company, 1207-1223 Columbus Avenue, Pittsburgh, Pa.—Folder describes special universal couplings for conduit work which eliminate the extra threading of pipe ends for ordinary couplings.

Ridgway Dynamo and Engine Company, Ridgway, Penn.—Bulletin 31 describes the construction and gives the advantages claimed in the operation of Ridgway turbo-generator sets.

Pittsburgh Transformer Company, Pittsburgh, Pa.—Bulletin 2033 describes the Pittsburgh distributing transformer, single-phase and polyphase. Bulletin 2030, describes the copper alloy steel tanks for Pittsburgh transformers. Bulletin 2031 describes the Pittsburgh expansion-tank type transformer.

American High-Speed Chain Company, Indianapolis, Ind.—Announcement is made and dimensions are given of standard stock sizes of chains and sprockets in several ratings ranging from 2 to 10 hp. with reductions of 3-, 4-, 4½- and 5-to-1, which are carried in stock.

General Electric Company, Schenectady, N. Y.—Circular 66022 entitled, "Outdoor Current and Potential Transformers," gives the characteristics and operating conditions as well as dimensions of this equipment for circuits up to 15,000 volts.

The Northern Blower Company, West Sixty-fifth Street and Wheeling and Lake Erie Railway, Cleveland, Ohio—Bulletins describe the line of direct motor driven exhaust fans, air filters and metal insulated ovens for core baking, mold drying and japanning.

Condit Electrical Manufacturing Company, South Boston, Mass.—A folder describes the Type N-4, oil motor starter for motors of 5 hp. or less on 600 volts or less.

H. Kleinhans Company, Pittsburgh, Pa.—A folder describes the "Uni-flo" welding wire, the different grades, sizes and composition and the purposes for which each is best adapted.

Buffalo Forge Company, Buffalo, N. Y.—Catalog 465 covers the line of unit heaters and their installation in various industrial plants. These heaters are easily installed.

Reminiscences of a Trouble Shooter

(Continued from page 184)

can be very greatly simplified by coating a portion of the commutator with shellac and applying very finely sifted sand. Rotate the machine slowly until a fit is assured. Then clean the commutator with alcohol. When using a stone of any kind on a commutator, I consider it to be the best practice, wherever possible, to shut down the machine and remove the brushes. Otherwise, the small particles tearing from the stone will cling to the commutator and destroy the life of the brushes by wear and giving them a coarse fit on the commutator when the operation is completed, with resultant dirt and blackening.

"If at any time it should be necessary to turn a commutator, great care must be taken to prevent chips from lodging in the risers. To prevent this, obtain a piece of muslin of sufficient length to go around the commutator and wide enough to extend a couple of inches beyond the risers. Lay this piece around the commutator and tie it as close to the risers as possible. Then lift the cloth off the commutator and over the risers and tie it in place over the top of the riser connections on the armature.

"Pete," said Ed at this point, "I wish you would warn your readers that in the application of any of the things I have told you, it will be up to the operator to use his best judgment as to whether or not they will be practicable for his application. I have found them beneficial in some instances, while in others they would not be applicable at all.

"Likewise, the solutions of troubles related apply to actual instances, but this is not *prima facie* evidence that they will solve every trouble. The point that I would like to emphasize is that a trouble may be more mechanical than is anticipated and more simple than it appears. Likewise, it may be a combination of the two arising simultaneously and, on the other hand, an apparent trouble of a mechanical nature with electrical trouble arising therefrom.

"In this connection, it was but a short time ago that I 'cut in' two turbo-generators with exciters attached. The switchboard was installed by a local firm and was giving trouble and to assist their man in testing his board I was running one of the turbos idle with 90 volts on the exciter. There was a momentary groan and all of his meters read backwards, which indicated a reversed exciter, yet only one of the exciters was in service. As it was past quitting time, we shut down for the night and on starting up the following morning the exciter could not be built up. Completely neutralized, it was. But after being re-excited from the other exciter it gave no further trouble.

"What had evidently happened was that the switchboard man had in some way completed the alternator field and immediately broken it, with the result that it discharged through the exciter and reversed it. This is an example of a very simple trouble that is known to exist and can and will cause an electrical trouble where no trouble existed previously. To get at the root of any trouble, obtain a thorough understanding of the mechanical and electrical principles involved in the operation of the equipment, and from this point work outward to your trouble. Leave the design and the engineering principles to the manufacturer."

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

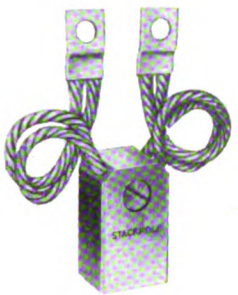
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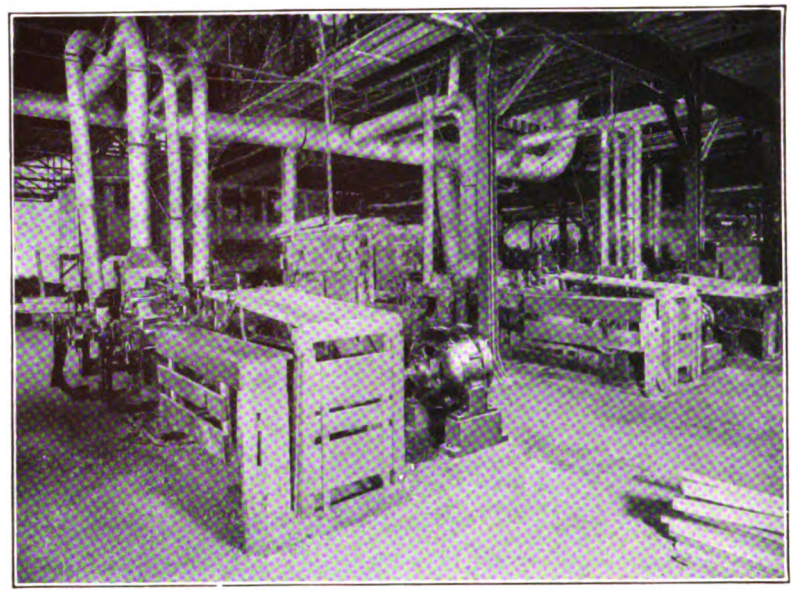
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Type "AR" Induction Motors
drive
Woodworking Machinery

Above is shown type AR Squirrel Cage Motors driving American molding machines in the Plant of the Watsontown Door & Sash Co., Watsontown, Pa.

These motors are exceedingly rugged due to their all steel frame construction. Their particular design makes for very thorough ventilation and a very accessible motor for cleaning. Allis-Chalmers power equipment is used almost exclusively in this plant.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 83 Chicago, May, 1925 *Number 5*

Variety May Add Spice—

But in the Case of Equipment It Does Not Promote Ease and Speed of Making Repairs

ONE of the things that I admire the readers of INDUSTRIAL ENGINEER for is the whole-hearted manner in which they hunt for every possible means of increasing the value and efficiency of maintenance work, to the end that production will not be interrupted by preventable breakdowns of equipment. They are men after my own heart.

This characteristic was forcibly brought to my attention the other day by the following letter from my good friend J. H. Gallant, who is associated with the Canada Cement Company, Limited, Belleville, Ont., Can.:

In this age of specialization, special machinery and specialists, everybody from the wide-awake and progressive executive down to the man on the job, is beginning to realize more and more the necessity for the standardization of materials and of methods of production as well as maintenance, on which production depends.

The standardization of methods is strictly up to the men directly in charge of production and of maintenance.

The high efficiency attainable through standardized methods of production, whether in the shop, the foundry or any other department of an industrial plant is now so generally recognized that hardly more than passing mention of it is necessary here. The benefits of standardization in maintenance methods are, however, not so generally recognized.

It is often a case of "Let Bill do it," and poor Bill, the repair foreman, does it the best he can. Oftentimes very little thought is given as to whether Bill and his men might not have been able to do the job in some easier way and in a much shorter time if they had had the advantage of having frequently done a similar job on the same kind of machine, so that they could use the same methods, the same tools and the same standard material.

Suppose a clutch breaks down, a motor develops a ground or burns out, the teeth get stripped off a gear, or a compensator or a switch is short-circuited. If the equipment in the plant is standardized, the repairman knows immediately what tools to take with him to the job; he knows what materials to draw from the storeroom; the storekeeper will find the materials more easily and save time.

When he gets to the job the repairman will know just how to go at it so as to do it in the easiest and quickest way. He will not have to go back and forth several times for tools and materials.

Ask any experienced repair foreman and he will tell you that on the small repair jobs, which constitute over 80 per cent of the breakdowns in industrial plants, as much and often more time is spent in getting ready for the job and in going back and forth for tools and materials, than in making the repairs.

The real loss, of course, is not in the time taken to do the job, but in the time the machines are idle.

With several kinds of equipment in use it takes longer to train the repairmen to a high degree of efficiency; they will generally take more tools than necessary, and often the wrong ones, and have to return for more material or for the right kind of material. Time lost is production lost.



Another quite important advantage of standardization of equipment is the smaller investment required to carry the necessary spare and repair materials, in the store space required, and the smaller staff with which it is possible to operate the storeroom.

The foregoing should by no means be taken as a brief for the retention of old and obsolete equipment. New and more efficient equipment is being brought out every day, and any change which will save time and promote efficiency, is a move in the right direction.

In replacing old equipment, we should, however, as much as possible, stick to one kind of machine or device for each job.

Practically every machine which has passed the experimental stage and has come to be used commercially has its good points, and when several machines for doing the same job are on the market it is often difficult to choose between them.

Unfortunately the ideal condition, where it is possible to buy a machine embodying all of the good points of the several machines offered for the same service, is very rarely attained in practice. We cannot get everything in one package.

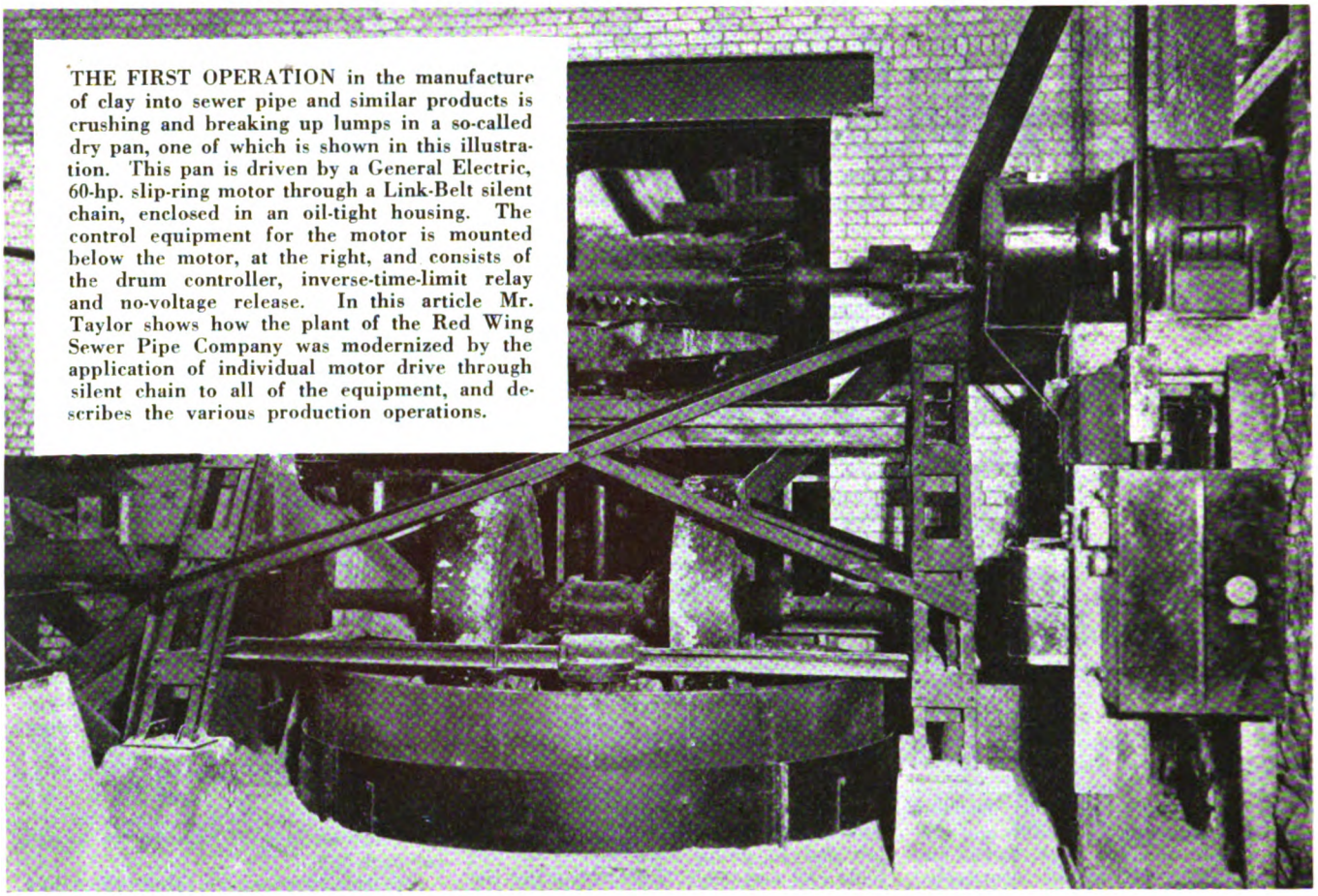
Nevertheless, after an intelligent selection has been made we should be willing to do without the few good points we have been unable to buy, and make up for them by concentration on the proper maintenance of what we do have.

The time thus saved on maintenance and production will much more than compensate for the few advantages that we may feel we are missing by not having other types of machines.

You may or may not agree with the views with Mr. Gallant has expressed, but I think you will agree with me that he has touched upon a very interesting subject, has presented some good arguments in support of his position, and has given us something to ponder over. In any case, I shall be glad to have you drop me a line and let me know what you think about this matter.

Practical Pete

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THE FIRST OPERATION in the manufacture of clay into sewer pipe and similar products is crushing and breaking up lumps in a so-called dry pan, one of which is shown in this illustration. This pan is driven by a General Electric, 60-hp. slip-ring motor through a Link-Belt silent chain, enclosed in an oil-tight housing. The control equipment for the motor is mounted below the motor, at the right, and consists of the drum controller, inverse-time-limit relay and no-voltage release. In this article Mr. Taylor shows how the plant of the Red Wing Sewer Pipe Company was modernized by the application of individual motor drive through silent chain to all of the equipment, and describes the various production operations.

Some Details of Power Drives with

Individual Motors and Silent Chains

That Have Resulted in Greater Economy in the Use of Power and a Reduction in Maintenance Cost and Accident Hazards

By DEAN W. TAYLOR

Formerly Power Engineer, Northern States Power Company, Eau Claire, Wis.

WHEN factory A of the Red Wing Sewer Pipe Company, Red Wing, Minn., was destroyed by fire in November, 1922, plans were formulated for rebuilding it and using equipment and methods that would provide the highest all-around operating efficiency. The products of this plant are sewer pipe, flue lining, wall coping, drain tile and similar clay products.

The old plant had been operated by means of a 250-hp. Corliss engine and the various machines had been driven from a system of lineshafts, countershafts, mule drives and bevel gears. While the old plant operators had become used to the original and out-of-date layout and were able by reason of long familiarity with the plant to find their way around in the semi-darkness, a stranger in going through the plant would have been impressed with the great value of an accident policy to anyone inspecting the equipment. Many reasons existed for improving the power application, and not the least of these reasons was safety. Briefly, in common with many other old plants, it contained numerous examples of obsolete methods and equipment.

The first thought of the management was to rebuild and get the plant into production again as quickly as possible. It was the intention to make the new building fireproof, but in the main the plant layout, methods of drive and so on were to be the same as in the old plant. However, at the suggestion of the engineers of the local power company, the officials of the Red Wing Sewer Pipe Company investigated the modernization of the new plant from the standpoint of machinery layout, power drive and power supply, as well as building construction.

Several considerations helped to put such a procedure in a favorable light. In the first place, the generation and use of steam power to drive the machinery in the plant had made the power cost high. Further, due to the fine clay dust which is present in the air, a great deal of trouble was experienced with the use of open bevel or other gears. Besides, these gears were very noisy. The fine dust would work its way into bearings, clog up oil holes, induce rapid wear of bearings and was generally troublesome. In the case of friction clutches, it caused them to drag when open, with consequent rapid wear of certain parts. This necessitated frequent repairs and replacements, making maintenance costs high.

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Types of Motors Installed and Machines Driven

Motor Hp.	Type of Motor	Machine Driven
5	Squirrel cage	Dry pan feed belt
60	Slip ring	Dry pan
5	Squirrel cage	Dry pan discharge belt
5	Squirrel cage	First dry clay elevator
10	Squirrel cage	Second dry clay elevator
5	Squirrel cage	Shaker screen
10	Squirrel cage	Wet clay elevators (2)
50	Slip ring	Wet pans (3)
5	Squirrel cage	Press storage belt
2	Squirrel cage	Press feed belt
3	Squirrel cage	Press follower drive
2	Squirrel cage	Press cut-off
10	Variable speed	Waste heat fan
5	Variable speed	Cold air circulating fan
7½	Special	Freight elevators (2)

After a good deal of investigation and discussion, it was finally decided to use individual motor drive on all machines, to drive the machines through silent chains protected by oil-tight housings, and to purchase the electrical energy required.

Considering the conditions in the plant, the use of individual motor drive presented the important advantage that it would permit the most efficient arrangement of production machines by allowing them to be placed in the proper location for handling the raw material, rather than where they would be most convenient for belting to the lineshafting. This was an important consideration, as in the layout of the old plant the location of the lineshafting had determined the location of the machines, oftentimes without more than passing regard for the flow of materials. Another advantage of the use of individual drive was the elimination of mule drives and bevel gears, which at best were not very satisfactory. In addition, the expense and trouble connected with the use of friction clutches were eliminated; injury hazards to workmen were greatly lessened; and the power losses due to friction between bearings and gears were much reduced. Lastly, the noise resulting from the operation of shafting, belting and gears was largely eliminated.

After the decision to use individual motors had been made, the question came up as to the type of drive. All machines to be driven operated at low speed; therefore, direct connection of motors and machines was not possible. In the end, silent chain drive was selected because it was felt that it afforded greater all-around efficiency than would be obtained with belts. Also, a positive drive would be obtained. Another advantage was that the use of chain drive would eliminate long belt drives through floors and walls. Likewise, it would eliminate belt maintenance and reduce the accident hazard incidental to the use of belts and gears, as all chains are enclosed in an oil-tight housing. There was also the advantage that better lighting could be obtained if chain drives were used because these would not interfere so much as do belts and lineshafts. As a result of the elimination of belts and lineshafts, and the possibility of better lighting, the general appearance of the plant would be considerably improved.

The reasons for the adoption of purchased power may be briefly summarized as: Greater economy as com-

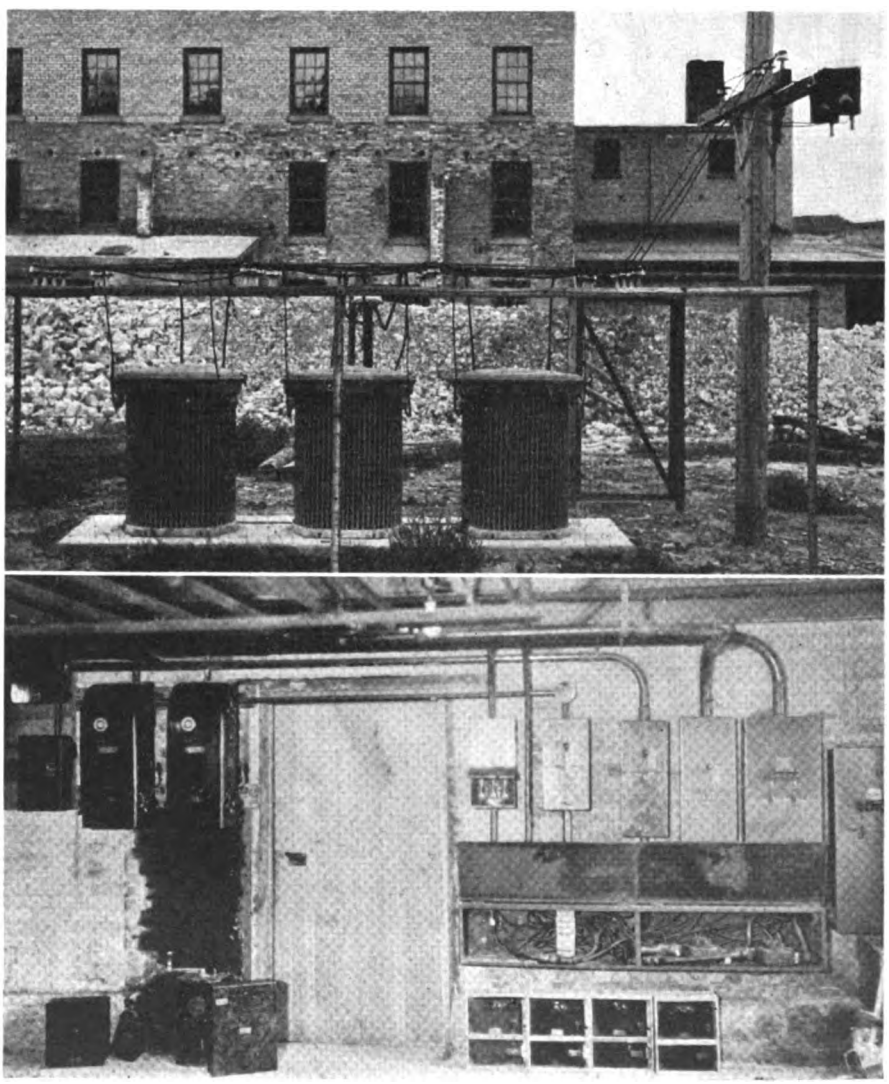


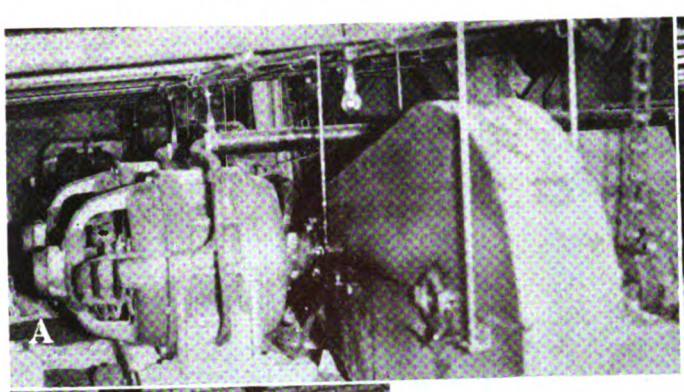
Fig. 1—Transformer substation, above, and service and feeder switches where power circuits enter the plant building.

Power for operating the plant is supplied by the Northern States Power Company at 6,600 volts, three phase, 60 cycles, and is stepped down to 440 volts by the transformers shown above. The 440-volt power is brought into the building through underground conduit, the outer end of which can be seen behind the middle transformer. Lighting service is supplied by transformers with 440-volt primaries and 110-220-volt secondaries. The lower illustration shows the service switch at the right and the safety, enclosed-type switches controlling the various circuits in the plant. The meter transformers can be seen in the cabinets just below the switches.

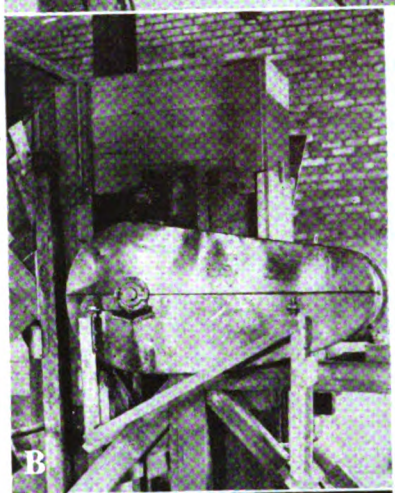
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Some Typical Silent Chain Applications

Individual Drives on Equipment in Clay Products Plant







A—These three 50-hp. slip-ring motors drive the wet pans, which are located on the floor above. The wet pans are shown in E.

B—Enclosed silent chain drive for wet clay elevator. The motor is rated at 10 hp. This elevator carries the wet, finely-ground clay from the wet pans to the top floor where it is discharged into a chute leading to the press storage belt which is shown in illustration D.

C—Grog, ground burned ware, is passed through this shaker screen before delivery to the wet pans. The screen is driven by a 5-hp. motor.

D—A 5-hp. squirrel-cage motor drives the press storage belt through an enclosed silent chain. The wet clay is carried by this belt from the chute into which the wet clay elevator discharges it, to the feed belt of the press.

E—These 9-ft. wet pans, in which the clay is ground fine, are driven through silent chains by the 50-hp. motors shown in A.

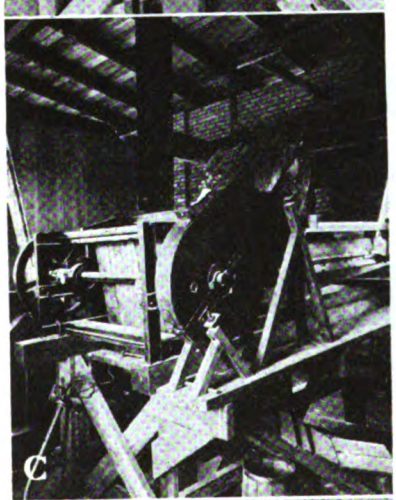
F—Steam cylinder of press which forces the wet clay through dies to form tile and other shapes.

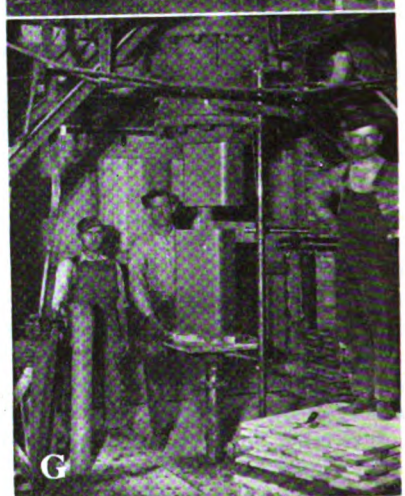
G—This shows the lower end of the steam press. Flue lining was being extruded when this photograph was taken.

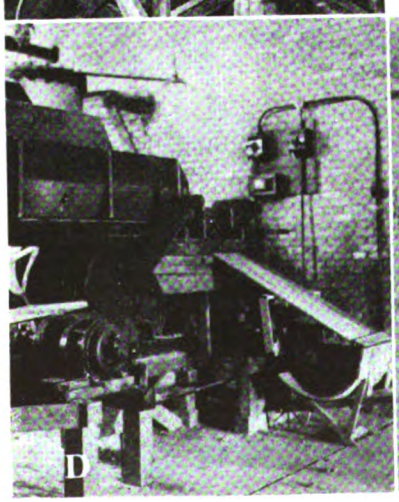
H—One of the two dry clay elevators, which are also driven through silent chains by 5-hp. motors.

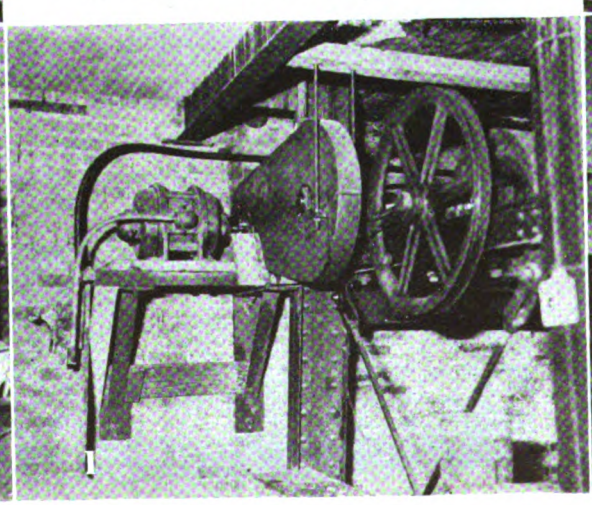
I—Individual 3-hp. motor and chain drive for press former shaft. This shaft carries a die which is forced into the end of the tile as it is extruded, to form the bell end

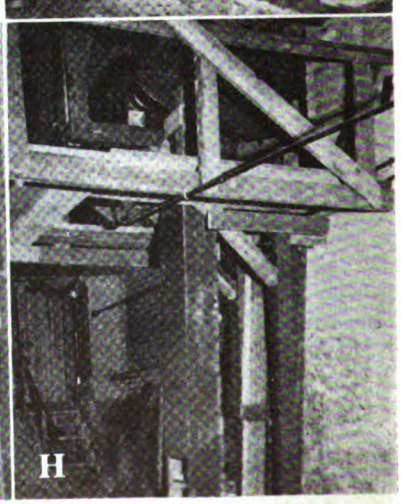












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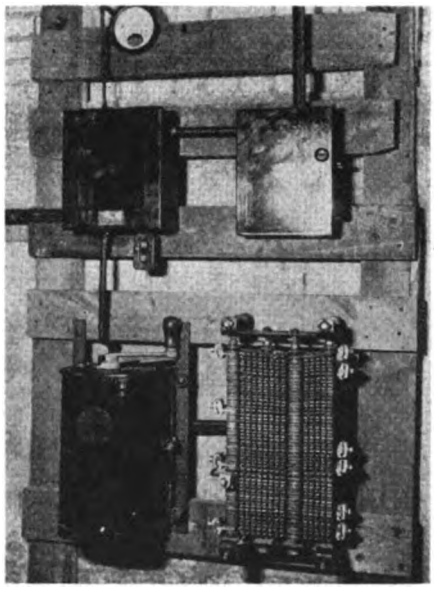


Fig. 2—Typical control panel for slip-ring motor.

The control equipment comprises a line switch, magnetic switch, drum controller, resistor and ammeter.

pared with steam power generated locally; greater flexibility in capacity of power supply; and continuous availability of service for operating fans, lighting service and the like at times when the plant as a whole was not running.

The new plant was put in operation in the early part of October 1923. At present, there are installed 19 General Electric three-phase motors with an aggregate rating of 352 hp. The type of motor used and the machines driven are shown in an accompanying table. A standard motor speed of 900 r.p.m. was selected for every drive, as this speed gave the most economical combination of proper chain speed, bearing load and motor cost. Further, a uniform motor speed makes interchangeability of motors both practicable and convenient. Link-Belt silent chains in oil-tight housings are used on all drives.

All wiring is in conduit and enclosed-type, safety switches are used on the control for each motor. Push-button emergency stop stations are used on all important drives. All motors over 5-hp. rating are protected by inverse-time-limit relays and no-voltage releases. Small motors are protected by thermal overload devices.

With central station service available during every hour of the day and night, it was possible to provide for an adequate lighting installation. The old lighting system, which consisted of an occasional 25-watt lamp, coated with oil and clay and supplemented by portable oil torches, was replaced by an installation of 100-watt, gas-filled lamps in RLM enameled steel reflectors spaced 14 ft., at a mounting height of 9 ft. The connected lighting load is about 32,000 watts.

Electrical energy is delivered by the Northern States Power Company at 6,600 volts, 60 cycles, three phase and is stepped down by the transformer substation shown in Fig. 1 to 440 volts, three phase. Current at 110-220 volts for lighting service is supplied by transformers having 440-volt primaries and 110-220-volt secondaries. The service switch as well as the switches which control the various circuits are shown in the lower illustration of Fig. 1. They are located in the wet pan room where the service wires are brought in to the building, and are very near the load center of the plant.

The service wires from the substation to the plant are 350,000-circ. mil, rubber-covered, single conductors. They are brought into the building through underground conduit, one end of which can be seen behind the middle transformer in the upper illustration in Fig. 1. Underground work was necessary here because of interference by a spur track upon which is operated a yard crane with a long arm covering a comparatively wide area. This crane is used for unloading clay and coal and for stacking sewer pipe and other products after firing. It is driven by a 40-hp. motor and carries 300 ft. of cable which is plugged into receptacles which are located at different points around the entire plant.

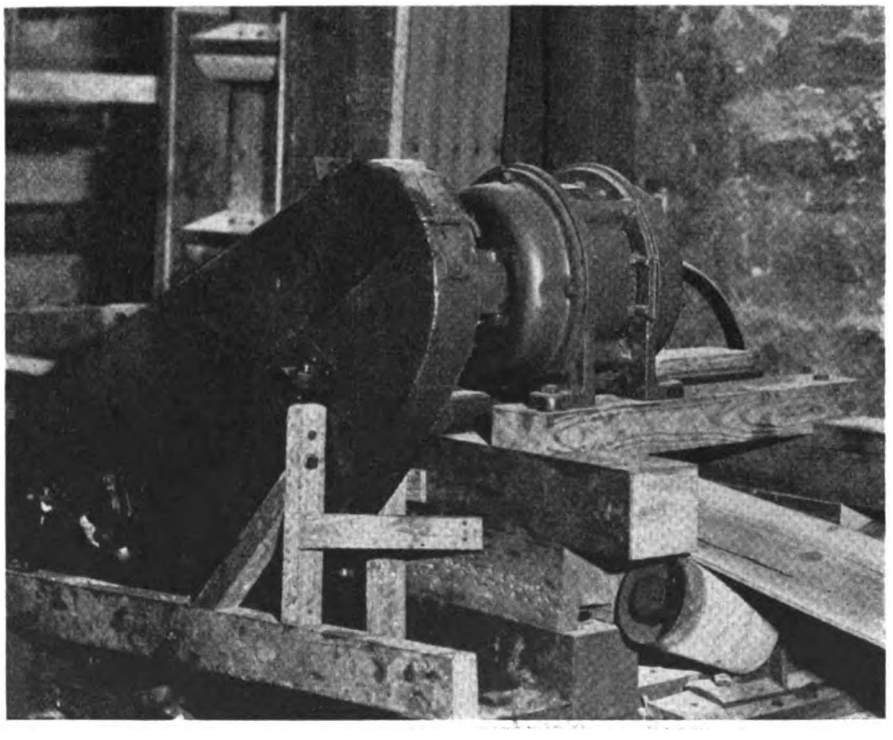
The maximum power demand amounts to about 225 kw. and approximately 30,000 kw.-hr. of energy are used monthly.

With this view of the equipment used, it may be interesting to see where and how it is employed in the manufacture of 75 tons of clay products a day. About 100 tons of raw clay are delivered daily to the plant and dumped into outdoor storage. This procedure makes it easier to select and properly blend the clay according to the product to be made. The first operation is rough grinding. The raw clay is dumped from storage onto a feed belt and into what is called a dry pan. This is a large, circular, shallow pan with a coarse-grated bottom, which revolves slowly. Two heavy iron rollers which are free to turn on a fixed shaft serve to break up the lumps of clay as the pan revolves. This pan, which is shown in the illustration at the head of this article, is driven by a 60-hp., slip-ring motor.

As the clay lumps are broken up sufficiently fine to pass through the

Fig. 3—Discharge belt which carries crushed clay from dry pan to elevators.

This belt is driven by a 5-hp., squirrel-cage motor through a silent chain. Note the oil-tight housing which encloses the chain. This housing is partly filled with oil and thus serves the double purpose of protecting the workmen and keeping dust and dirt away from the chain, as well as insuring ample lubrication.



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grating of the dry pan, the fine material falls onto a discharge belt which is driven by a 5-hp., squirrel-cage motor. This belt, the drive end of which is shown in Fig. 3, discharges the clay into the boot of an elevator which carries it to the top of the factory building where it is discharged into dry storage. A portion of this elevator is shown in *H* of the illustration on page 216. The clay is held here for a few hours and then is dumped into the hopper leading to one of the wet pans.

These are similar in construction to the dry pans, with the exception that the bottom is solid instead of grated. In these pans the clay is ground fine and mixed with water. About 5 per cent of grog, ground burnt ware, is added to give it the proper consistency. The grog is taken from separate storage and passed through a shaker screen before it is delivered to the wet pans. The shaker screen is driven by a 5-hp. motor and is shown in *C* of the illustration on page 216. The wet pans are driven by 50-hp., slip-ring motors which are located on the floor below. These motors are shown in *A* on page 216. In this case, the speed reduction is from 900 r.p.m., the motor speed, to 175 r.p.m. These wet pans are shown in *E* on page 216. It will be noted in this illustration that the drum controller and protective devices for the motors which drive these pans are mounted on nearby building columns. In addition, several push-button stations for each wet pan are located at convenient points so that in emergency any pan can be stopped at once.

When the charge in one of the wet pans has been properly ground, it is swept out of the pan by a movable arm or baffle and discharged into an elevator and carried to the top floor. Here it is discharged into a chute and then onto a storage belt. An operator transfers the wet clay as required from the storage belt to a feed belt leading to the hopper of the press which extrudes the clay in the form of sewer pipe or other shapes. The storage belt is driven by a 5-hp., squirrel-cage motor through silent chain and is shown in *D* on page 216. The press feed belt is driven by a separate 2-hp., squirrel-cage motor.

The press consists essentially of a steam cylinder, 4 ft. in diameter, which under a steam pressure of 100 lb. per sq. in. forces the wet clay through a die, thus forming the pipe. Views of the upper and lower portions of the press are shown in *F* and *G* on page 216. At the time this photograph was taken, flue lining was being drawn. As the extruded clay leaves the die of the press the forming die supported on the vertical shaft, which is raised and lowered by a separate small motor, is forced into the end of the pipe to form the bell end. Illustration *I* on page 216 shows the 3-hp. motor and chain which drive the press former shaft. The pipe is cut off in standard lengths, placed on small carts and taken by elevators to one of the three drying floors where it is dried by means of the waste steam from the press. This steam is circulated through coils located about 7 ft. above the floor. A temperature of approximately 110 deg. F. is maintained on the drying floors and the moisture given off by the green ware passes off through the monitor-type roof. After the green ware is sufficiently dry, which usually requires from two to eight days for different sizes of pipe, it is burned in a coal-fired, down-draft kiln for 80 hr.

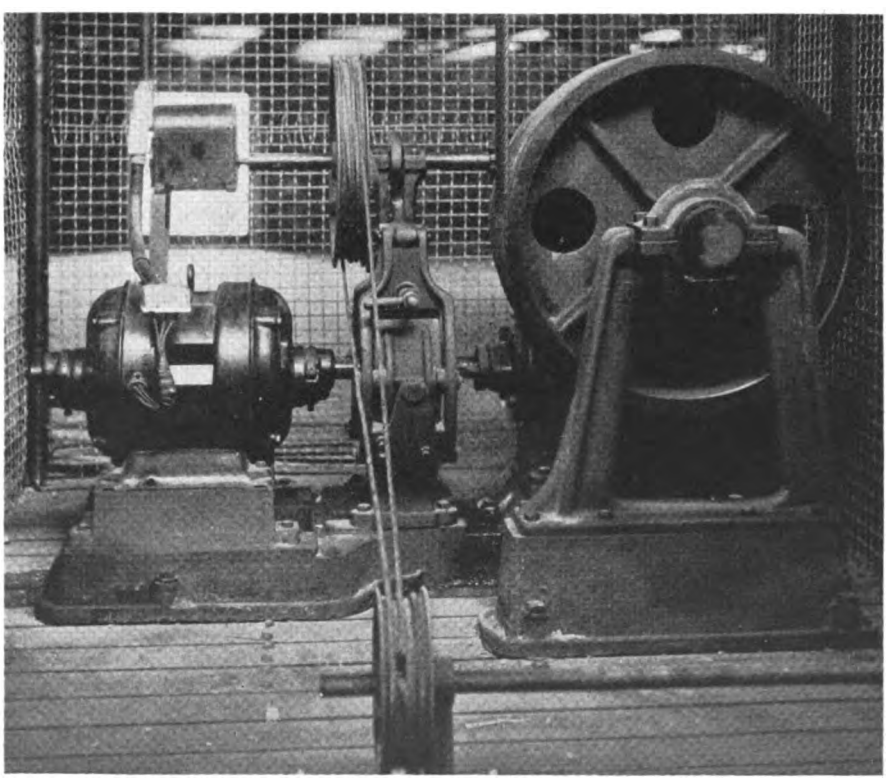


Fig. 4—Winding machine of one of the freight elevators in the dryer. There are two elevators of this type, each driven by a special 7½-hp. motor. These elevators carry the green ware to and from the dryer prior to firing in the kilns.

Maybe You Haven't Noticed It, But—

It has been my experience that the man who is an expert at making excuses is seldom much good for anything else. We all have to admit at times that we have fallen down on the job because we either did not have the ability or the persistency to carry a certain job through to the finish. But when you stop to think of it, these are damaging admissions, as the lawyers say. Lack of brains is a mighty poor argument when raise-day comes around, while lack of persistency somehow always makes me think of yellow.

There aren't many jobs which are absolutely impossible to do; so the chances are that you and I won't get one handed to us very often. Consequently, when I have to explain to myself why I haven't done as directed, I always feel that, instead of saying something which sounds wise and plausible, I ought to say, "Boss, I'm not as good a workman as you think I am. I didn't have brains enough to do that job, nor gameness enough to keep right on trying, nor ambition enough to hustle around and find out how to do it. So I guess you had better give all of the real jobs to somebody else." Then I get right down to business and by that time the job's done. All any man needs to do in a tight place is to be fair with himself and use his mental equipment in doing the job, not thinking of excuses.

Practical Pete

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This illustration shows a general view of the Meter Department. The workman in the center is polishing the pivot of an armature shaft, which is mounted in a small lathe. In the background a polyphase meter is being tested and adjusted at the test bench. The shelves above and to the right contain part of the stock of measuring instruments.

Procedure in

Overhauling Electrical Measuring Instruments

With Details of Defects Most Commonly Found, How They Are Remedied, and Methods of Testing After Repairs Have Been Made

By J. D. ZOOK

Superintendent, Gregory Electric Company, Chicago, Ill.

REPAIRING and testing electrical indicating and recording instruments resembles watch or clock repairing much more closely than it does the repairing of motors and other electrical equipment. Most of the parts are so light and delicate that very careful handling is necessary, while the operations and adjustments that are required must be made with an accuracy and precision that are seldom called for in repair work on ordinary types of electrical equipment. In our *Meter Department* we overhaul completely several thousand electrical meters of various kinds a year and a brief account of what the work involves and the methods which we use may be interesting.

Inasmuch as a large part of the work in the *Meter Department* is overhauling watt-hour meters, we will consider these instruments first. In order, however, that the reader may clearly understand some of the operations which will be described it may be well to consider what a watt-hour meter consists of and how it operates.

A direct-current watt-hour meter is essentially a small shunt motor whose armature revolves at a speed that is proportional to the rate at which electrical energy is passing through the meter. A small worm gear is cut into the upper part of the armature shaft so that the latter is geared through a train of small gears to a number of recording dials. These dials thus indicate at all times the total amount of energy that has passed through the meter since it was installed.

In two-wire meters two stationary coils connected in series with each other and with the line supply the field. These are known as the current coils. In three-wire meters the coils are in series with the line. As there is no iron in the fields the field strength is obviously proportional to the current passing through the coils. The armature, which is also called the moving element, or potential element, is vertical and consists of several coils of fine wire, the ends of which are connected to a silver commutator. The coils and commutator are mounted on a long, slender shaft. Two silver-faced brushes make contact on the commutator and supply current to the armature winding, which is termed the potential coil. A resistance and a small shunt coil are connected in series with the armature winding and this entire circuit is, in turn, connected

ELECTRICAL measuring instruments are an indispensable part of the electrical equipment of every industrial plant. They give us all of the many facts which we must know in order to apply and utilize electrical energy efficiently, without undue waste, and with the least danger of injury to the equipment. Such instruments are necessarily of delicate construction and must be carefully handled and periodically checked up and overhauled, if dependable readings are to be obtained. In this article Mr. Zook tells some of the things that happen to measuring instruments in service and describes the methods of repairing and testing that have been developed through years of experience in this work.

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in parallel with the line. As the strength of the field flux is proportional to the current flowing in the field or current coils, and the current in the armature coils is proportional to the voltage across the line, the torque of the armature is equal to the product of these two, or the watts.

It is plain that unless some sort of brake or load were imposed on the armature the latter would rotate at a comparatively high speed; also a weak current would cause it to revolve almost or quite as fast as would a stronger current, so that the instrument would be of little or no value. A large aluminum or copper disk is, therefore, mounted on the lower part of the armature shaft and made to rotate between the poles of two strong, permanent magnets, known as drag magnets. The disk does not touch these magnets, but as it rotates between the poles, cutting the lines of force sets up eddy currents in the disk, which oppose its motion and act as a drag. This drag or retarding effect is exactly proportional to the speed.

In order to reduce friction as much as possible, the lower end of the armature shaft is supported on sapphire or diamond jewels. Although two or three different types of jeweled bearings are in use in different makes of meters, as will be explained later, they all accomplish the same ends. Inasmuch as there is no weight on the upper bearing, the latter serving merely to hold the armature vertical and keep it from tipping, this bearing usually takes the form of a fine steel pivot or point which fits into a small hole or recess drilled into the upper end of the armature shaft.

All induction-type, alternating-current watt-hour meters operate on the same general principle, which is much like that of the induction motor, and for the most part differ only in some of the details of construction.

Briefly, the essential elements are two sets of windings, known as the current and potential windings, which are arranged so that a rotating magnetic field is produced which cuts a short-circuited moving member and makes it rotate. The current or series winding consists of two practically non-inductive coils wound with a few turns of comparatively large wire. These coils are wound in opposite directions and are connected in series with the circuit. The

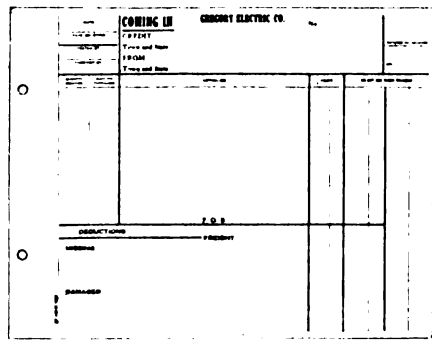


Fig. 1—This form is made out upon notification that a shipment of meters is on the way.

The Shipping Department holds this form until the meters come in. After the shipment has been checked for quantity and condition upon arrival the meters are sent, with this form, to the Meter Department.

current coils are usually mounted on laminated iron cores or poles, which direct the magnetic flux toward the rotor or moving element.

The potential winding comprises potential and impedance coils which consist of a large number of turns of fine wire and are mounted on laminated iron cores so as to produce a large phase displacement of the field. The potential coils are connected directly across the circuit, either alone or in series with a separate impedance coil.

The rotor or secondary is disk- or cup-shaped and is made of aluminum. It is mounted on a shaft which is supported on jeweled bearings and is so placed that it rotates through the magnetic field produced by the current and potential windings. As

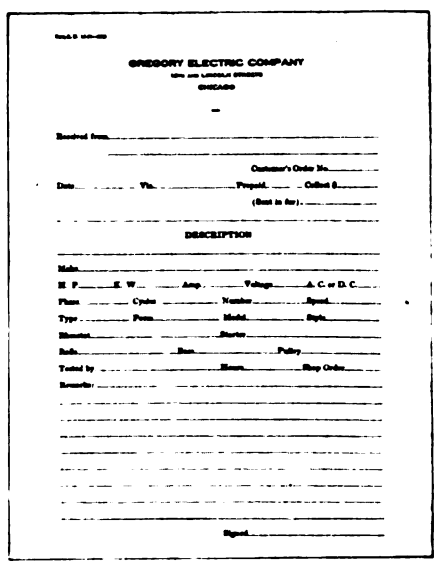


Fig. 2—A record is made on this form of all instruments which are sent in for repairs.

This record form, which is used for all equipment that comes in for repairs, is sent along with the shipment to the proper department, in this case the Meter Department.

before, the rotor also revolves between the poles of two permanent magnets which, by reason of the eddy currents which are set up, tend to stop the rotation and thus serve as a regulating device.

Electrical measuring instruments come to our *Meter Department* in three different ways, so to speak. That is, we have purchased them, to be overhauled and sold; they have been offered to us for sale; or they have been sent in for repair by some outside concern. The general routine and order forms for handling equipment from the time it is received in our plant until it is finally disposed of, were described in my article in the August, 1923, issue of INDUSTRIAL ENGINEER, but for the sake of completeness brief mention may be made of it as we go along.

If the meters have been purchased by us, a *Coming In* order is made out on the orange-colored form shown in Fig. 1. This form is sent to the *Shipping Department* and held until the shipment comes in. Upon arrival it is checked for quantity or number of pieces and the instruments are sent, along with the *Coming In* order, to the *Meter Department.*

If the meter or meters have been sent in for repairs one copy of the white form shown in Fig. 2 is made out and sent with the shipment to the *Meter Department.* In any case, a white tag is made out, showing by whom the meters were sent in, and wired to the instruments.

The first step is to make a thorough examination of each meter to determine the nature and extent of the repairs needed. This involves taking it all apart and testing the coils, examining the pivots, jewels and so on with great care. If the meter has been sent in for repairs the customer usually requests that we give him an estimate of the cost of doing the work. In many cases only comparatively minor repairs are needed. Often, however, the meter is in such poor condition that it is not worth repairing; that is, repairs would cost about as much as a new or overhauled meter. In any case, we notify the customer of the results of our examination and put the meter aside until he lets us know what his wishes in the matter are.

Substantially the same procedure is followed in the case of meters which have been purchased, or which have been offered to us for sale. If we find that a meter which we have

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purchased is in such condition that the cost of repairs will be excessive, we junk it. If it has been offered to us for sale and we find that we cannot overhaul it at a reasonable cost, we return it to the customer, or make some other mutually satisfactory arrangement.

A good many things can happen to a meter through abuse, accidents or neglect, so that while many of the instruments which come to us are in very fair condition many others have almost everything the matter with them. For example, oftentimes a meter is dropped. This will almost invariably break the jewels or the pivot, or both. In addition, other damage may be done. Or in the case of a watt-hour meter, it may have been allowed to run for 10 or 15 months without oiling or other attention, with the result that the glass-hard pivot cuts into the jewel bearing, to the consequent detriment of both. This condition will make the moving element rotate more slowly, so that it reads low. Usually this condition is discovered only when the meter is checked up or recent readings are compared with those taken previously. Again, a short-circuit or unduly heavy load will burn out the current coils; or lightning will burn out the potential coils, and occasionally wreck the entire mechanism.

Assuming, however, that the meter is not in too bad condition for repairs to be made at a reasonable cost, each part is gone over in turn and the necessary work done on it. Usually the first step is to give the entire meter a thorough cleaning. To this end all of the parts except the coils are cleaned by immersing them in clean benzine. This treatment will remove all of the old oil and dirt. When the coils of a meter have been thoroughly roasted, through an overload or other mishap, the entire mechanism is covered with a dirty, brown deposit which can best be removed by immersing the parts for a short time in a strong, boiling-hot solution of lye. For this operation the gear train is disassembled and the gears strung on wires. Upon removal from the lye the parts are rinsed in clean water and given a quick dip in a mixture of equal parts of nitric and sulphuric acids, full strength. This dip brightens up the metal and is followed by a rinse in cold water and then immersion in hot water, to remove all traces of acid. Inasmuch as the parts are then hot they can easily be dried by shaking them in sawdust for a moment.

If the finish on the cover of the meter is in good condition it is rubbed up and polished. Otherwise the old finish is removed by immersing the cover in the lye solution preparatory to refinishing it. We refinish covers by giving them three coats of Black Railway Rubbing Varnish. Each coat is baked on by keeping it at a temperature of 300 deg. F. for three or four hours.

We are then ready to make such repairs to the meter mechanism as may be necessary. Beginning with the armature or moving element, the pivots are carefully examined under a magnifying glass to determine just what condition they are in. If a pivot is broken or badly worn it is replaced. The lower pivot is screwed into the lower end of the armature shaft, so that replacing it is simply a matter of unscrewing the old pivot and putting a new one in its place.

It may be noted here that the lower pivots are of two general types. One type of pivot resembles those used in clocks and watches and is formed by turning down the end for a distance of about $\frac{1}{16}$ in. to approximately the diameter of an ordinary pin. The bearing used with this type of pivot consists of a sapphire ring- or hole-jewel resting on a cap jewel or endstone. The pivot passes through the ring jewel and rests on the cap jewel, which thus bears the entire weight of the moving element.

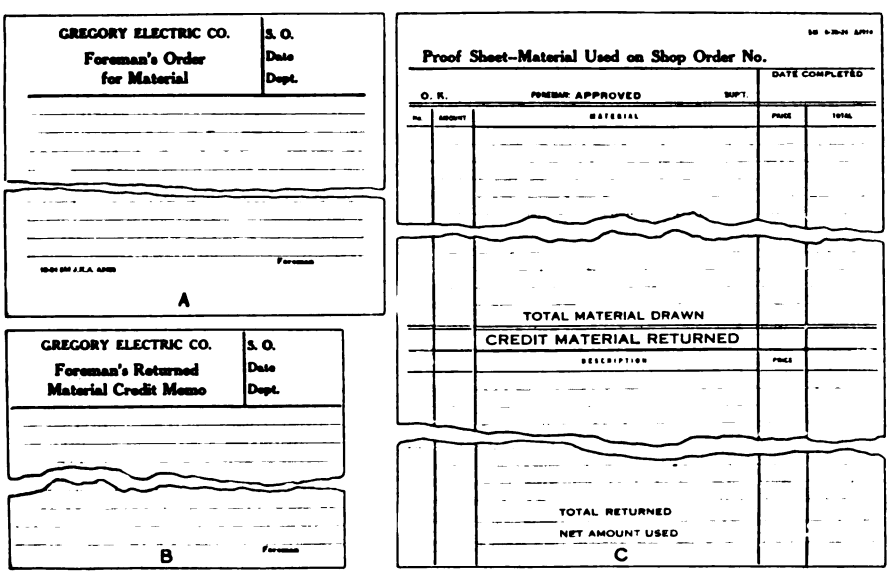
In the other type of pivot the end of the armature shaft is not turned down, but is rather sharply rounded, like the end of an egg, and rests on a cup-shaped sapphire jewel. In Westinghouse meters still another type of bearing is used. The armature shaft rests on a jewel which in turn rests on a very small steel ball supported on a cup-shaped jewel.

A radically different method of supporting the armature shaft is employed in Sangamo mercury-type meters. In these the shaft is supported on a disc immersed in mercury. In this case there is some thrust against the upper bearing, which is made up of a ring-jewel and endstone.

In the course of time, and particularly if they are not oiled occasionally, pivots become rough and worn and require polishing. This operation is performed by chucking the shaft in a small lathe, similar to those used by jewelers, and grinding the pivot smooth with a fine oil stone. Then it is polished with worn crocus cloth and the final finish given by polishing it with a piece of leather. As a rule the upper bearing, except in Sangamo meters, does not require any particular attention. In Sangamo meters, as noted before, the upper bearing is of substantially

Fig. 3—When material is withdrawn from or returned to the storeroom these forms are used.

Supplies are given out by the storekeeper only on receipt of the form shown in *A*, which bears the shop order number of the job. The storekeeper sends these tickets to the office and enters on the upper part of *C*, which is held by the foreman, the kind and quantity of material disbursed. If the foreman of the Meter Department wishes to return any material for credit, he sends it back to the storeroom with the ticket shown at *B*. The storekeeper then gives this department credit for the returned material by making the proper entries at the bottom of form *C*. The amount of material used on any job is thus easily found. When the job is completed the forms are sent to the office and filed under the job number.



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the same construction as the lower bearing in many of the other meters, and receives the same treatment.

If the meter is of the commutator type the commutator is, if necessary, smoothed down with very fine, worn crocus cloth and polished with silk tape. The brushes are similarly smoothed and polished.

Although the jewels are extremely hard, they are also brittle and for that reason are usually broken if the meter is dropped or otherwise roughly handled. We inspect the jewels carefully and if they are damaged in any way they are replaced with new ones obtained from the manufacturer.

If the current or potential coils, shunt, resistance and the like are damaged or burned out we replace them with new parts supplied by the manufacturer of the meter. We do not attempt to wind our own coils, as we find that little or nothing is gained by so doing, although we are equipped to make almost any part that might be needed, with the exception of jewels. In this way every part of the meter is carefully gone over and any repairs or replacements necessary to put the meter in first-class shape are made.

It is, of course, necessary to keep track of the material used and the time spent in making repairs, and we have a simple but efficient system for doing this. Every job has an order number against which all time and material are charged. Material is requisitioned from the storeroom on the form shown in Fig. 3, *A*. As these tickets come in the storekeeper enters the kind and amount of material called for on the form shown in Fig. 3, *C*. Any material which the foreman of the *Meter Department* wishes to return to the storeroom is sent back along with the form in Fig. 3 *B*. The proper entries are then made at the bottom of the form in Fig. 3 *C*. When the job is completed all of the tickets are turned in to the office and filed under the order number. The time tickets turned in by the men bear the order number of the jobs they have worked on. In the office the entries on the time and material tickets are transferred to a cost sheet, from which the entire cost of any job may be obtained.

After all repairs have been made, assembly and testing of the meter are then in order. For present purposes the only point in the assembly which needs to be mentioned is the oiling of the jewel bearings. It is highly important that only the finest grade of clock or meter oil be used for this purpose. Inferior oils will soon become gummy and cause the meter to run slow.

Testing watt-hour meters is, of course, one of the most important steps in the overhauling process. Unless a meter is properly adjusted it will not function properly, no matter how carefully the repair work may have been done. Testing is a subject about which a great deal could be said, but at this time it is possible to indicate only some of the more important points.

As everyone knows, there are three general methods of testing watt-hour meters: namely, (1) by the use of indicating instruments; (2) by comparison with rotating standards; and (3) by the use of a calibrated resistance. We use the first-named method wherein, in the case of direct-current meters, the power passing through the meter is measured by an ammeter and a voltmeter and the time required for the moving element to make a certain number of revolutions is determined with a stop watch.

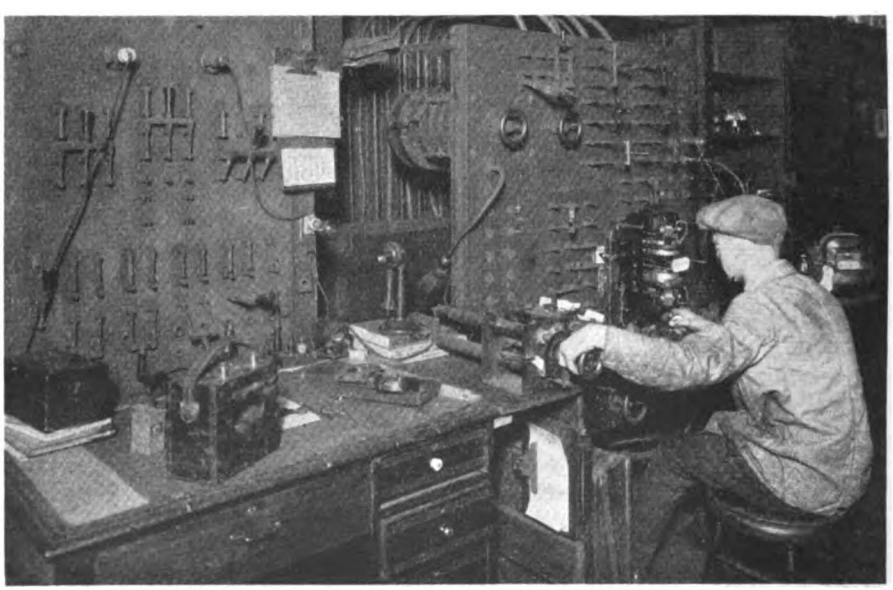
First we always check the dial register and gear ratio, to see that these are correct. We know that the moving element of a given meter should make a certain number of revolutions per minute when a certain amount of power is passing through the meter. When making a test, therefore, we put on the meter a load corresponding to full load, and the time required for the moving element to make ten revolutions or so, depending on the constant, is noted. At this time the meter is, of course, going too fast or too slow. If it is going too fast, that is, if the time required for the given number of revolutions is less than it should be, the drag magnets are moved slightly outward, or away from the shaft, to increase the retarding effect and thus slow down the meter. Conversely, if the meter is going too slowly, the drag magnets are moved in toward the shaft. The test is then repeated and the magnets again adjusted until the moving element rotates at the proper speed. The load is then decreased to 10 per cent of the full-load rating of the meter and the tests again repeated, with such adjustments as may be necessary, until the moving element is rotating at the proper speed at this load.

The meter is then tested for creeping, which is a slow rotation of the moving element when there is no load on the meter. In general, creeping may be due to one or more of the following causes: (1) Incorrect compensation for friction. (2) Vibration, which may reduce the friction sufficiently to cause rotation. (3) Stray fields. (4) Too high voltage. (5) In the case of three-wire meters connecting the potential circuit on the load side of meter when

(Please turn to page 259)

Fig. 4—Testing a polyphase wattmeter after overhauling.

The tester is checking each phase separately by taking with a stop watch the time required for the moving element to make a certain number of revolutions while full-load current, as shown by an indicating wattmeter, is being passed through the meter. From these test boards current of any desired voltage, frequency or number of phases can be obtained. Power is supplied by a number of motor-generator sets, not shown here.



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SLING CHAINS are most frequently overloaded because the men using them are either careless or ignorant of how they are abusing them. Comparatively few men realize that they can overload a chain when lifting a weight much below the rated safe working load of the chain. How this is possible is only one of the important considerations in chain service which are taken up in this article.

Some of the More Common

Ways in Which Sling Chains Are Abused

Together With a Short Discussion of Some Important Principles of Chain Loading Which Are Often Misunderstood or Overlooked in Practice

By DAVID FLIEGELMAN
Chain Design Division, American Chain Co., Bridgeport, Conn.

ASSURANCE that the chain is of ample size is perhaps the most important consideration when selecting chains to be used for hoisting heavy loads. This includes chains used on slings, cranes, dredgers and on other similar work where the chain is subjected to extremely severe usage. Manufacturers of chains give a safe working load rating which should not be exceeded.

In other words, a chain should be ordered sufficiently heavy for the work it is to do and at no future time should it be put to more severe use. It is not enough to know that the load lifted is below the safe load for that chain. There are other ways in which the safe load of a chain may be exceeded, even though the weight lifted is below the rated load. How that may be done will be explained later in this article.

In plants where human life may be endangered or where expensive machinery may be damaged by falling loads, chain manufacturers usually recommend dredge-quality, wrought-iron chains for service. Steel chain is not ordinarily recommended for use where loads are handled above the heads of workmen, or in other places where a dropped load would be dangerous. In some places where no particular hazard is involved, a steel chain may be used with entire satisfaction.

The reliability of any chain depends upon the quality of the welds and the material of which it is made. Because of the physical characteristics, which will permit the chain to suffer considerable abuse before fracture occurs, wrought iron is the best material to use. The quality of the iron can be obtained from laboratory tests; the quality of the welding is indicated by the "proof test" and careful inspection.

Chain should be proof-tested before using, as no chain is safe unless so tested. This is usually done by the manufacturer, who will furnish a certificate to that effect whenever requested to do so. The proof-test consists simply in applying a test load which is above the safe working load. This stress will be below the yield point of the metal but high enough to open any improperly welded links. High proof-tests deform the links and strain the material so that the shock-resisting qualities of the chain are depreciated. The safe working load rating of the chain would ordinarily be considerably below the load to which the chain has been proof-tested. Careful inspection after proof-testing will indicate any cracks or other signs of poor welds which did not show up beforehand.



Here the load is lifted without extra strain on the chain due to twisted links or to a wide angle between the branches of the sling. The National Safety Council, however, points out that the man at the right is endangered by using his hands to guide the chain.

Overloading is perhaps the most serious service abuse to which chains may be subjected. The strength of a chain may be seriously impaired by overloading it. Overloading has no relation to the age of a chain, as even a new chain may be impaired within a comparatively short time. The natural elasticity of the wrought iron is sufficient to take care of any proper or safe loading, if this is within the manufacturer's rating. If not overloaded or stressed beyond the limit of elasticity or yield point the chain will regain normal shape as soon as it is relieved of its load. When stressed beyond its yield point by an overload, the metal in the link does not go back to normal condition or shape after the load is removed. When the yield point of the metal is once passed by an overload the metal is never as strong as before.

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Because of improper application the total actual stresses set up in the links may be far in excess of those due merely to the weight of the load lifted. These increases in stresses in the chain due to improper use of the chain often have more serious results than an actual overload. These increased stresses may be due to any of the following causes: (*a*) Sudden application of load, shocks and sudden jolts. (*b*) Twisting of chain, kinks in chain and crossing of chain. (*c*) Bending of links around sharp corners. (*d*) Large angles between the branches or legs of double sling chains.

Of all of these four ways of abusing sling chains, probably the one least understood and appreciated is the last. The table below shows the safe working load for double sling chains under various conditions of attaching the hook to the load. It will be noted in this that as the angle between the two chains increases and the angles between the chains and the load decreases a lower safe working load may be handled. This is because that as the angle increases between the two chains the tension in each branch of the sling increases. While this is easily understood by those who have studied mechanics or mathematics, it is somewhat difficult to explain. The drawing on page 227 will, however, illustrate how this load is increased in each branch of the sling, although it does not explain why nor wherefore.

The arms of the two men carrying the traveling bag represent a double sling chain (inverted) with one arm of each person taking the part of one branch of the sling. While the two men stand close together with their arms down straight and parallel, each carries one-half of the load without much effort or strain on the arm. However, as the men step farther apart, the angle between the arms increases and as it does so, the load or pull which each man must exert to hold the traveling bag in the position shown increases. The strain on the men in positions *E* and *F* would far exceed their ability to stand the strain. In the same way a chain is overloaded.

When the angle between the branches is 170 deg., or the angle between the chain and the load 5 deg., as shown in the right-hand column of the table at the right, the safe working load is only 10 per cent of the safe load when the chains are almost vertical. In other words, the stress in these chains, if the same load were lifted in each case, would be about 11½ times as great with the chains at a wide angle, as when the chains are vertical. Half of this load would be taken by each branch of the chain. However, this stress would exceed the factor of safety of three and one-half to four, which is ordinarily used in a chain. Thus the stress or overload may be great enough to rupture the chain even though a load much heavier could be handled with safety if the chain had been applied differently.

It will be noticed that when the angle between the chains is 120 deg., or the angle between the chain and the load 30 deg., that the stress on each chain is equal to the total load. This angle might be considered as the absolute maximum at which sling chains should be used, and a much smaller angle would be preferable.

Practically the only method of preventing any of these abuses of chains is to know the effect of them and exercise care to prevent them. An inexperienced man should not be assigned to the task of adjusting or placing chains on loads that are to be lifted.

Repeated overloading of chains produces fatigue which weakens the chain sufficiently so that it may break sometime later even though it is loaded below its safe working load. The unsafe condition of the chain does not always show up when the overload is applied. A good wrought-iron chain will usually indicate that it is in an unsafe condition before actually rupturing. One of the most obvious indications of an unsafe chain is elongation which may be due either to deformation of the links, or to inter-link wear.

Deformation of the links is due to overloading, which makes the links narrower and longer, and destroys their elliptical shape; consequently, the chain loses its shock-absorbing properties. Results of tests show that in consequence of the deformation of the links and strain or fatigue of the metal, the chain becomes brittle. The wear on the inner surfaces at the ends of the links, where they "bottom," is due to the

How Stresses Increase in Branches of Sling Chains

Angle Between Branches in Degrees	Ratio of Pull to That with Branches Vertical	Per Cent Increase of Pull over That with Branches Vertical
10	1.004	0.4
20	1.015	1.5
30	1.035	3.5
40	1.064	6.4
50	1.103	10
60	1.155	15
70	1.221	22
80	1.305	30
90	1.414	41
100	1.556	56
110	1.743	74
120	2.000	100
130	2.366	137
140	2.924	192
150	3.864	286
160	5.759	476
170	11.474	1,047

NOTE: When the chains are vertical the pull is equal to the load. As the angle between the branches of a double sling chain increases, the pull also increases in the ratios and percentages shown. Under ordinary conditions half of the load would be taken by each branch of the sling.

Safe Load in Pounds for Double Sling Chains Under Different Loading Conditions

SIZE OF CHAIN INCHES	SAFE LOAD FOR SINGLE CHAIN	WHEN USED AT 60° ANGLE	WHEN USED AT 45° ANGLE	WHEN USED AT 30° ANGLE	WHEN USED AT 20° ANGLE	WHEN USED AT 15° ANGLE	WHEN USED AT 10° ANGLE	WHEN USED AT 5° ANGLE
¼	1,100	1,900	1,550	1,100	750	570	380	190
⅜	2,700	4,700	3,800	2,700	1,850	1,450	940	470
½	4,500	7,800	6,350	4,500	3,100	2,300	1,570	780
⅝	6,900	12,000	9,750	6,900	4,700	3,550	2,400	1,200
¾	10,100	17,500	14,000	10,100	6,900	5,200	3,500	1,750
⅞	14,000	24,000	19,500	14,000	9600	7,250	4,900	2,400
1	18,600	32,000	26,000	18,600	12,700	9,650	6,500	3,200
1¼	28,800	50,000	40,500	28,800	19,700	15,000	10,000	5,000
1½	40,800	70,000	57,500	40,800	28,000	21,000	14,000	7,000
1¾	52,500	91,000	74,000	52,500	36,000	27,000	16,000	9,100
2	66,600	115,000	94,000	66,600	45,600	34,500	23,000	11,500

NOTE: The drawings in the heading show the application of the chains to the load. When the angle between the chain and the load is only 5 deg. the safe load is only 10 per cent of the safe load when the angle is 60 deg. This may be compared to the chart showing analogous loading between chains and men carrying a hand bag by subtracting the sum of the two angles indicated here from 180 deg. to give the angle between the two branches of the sling.

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links rubbing against each other under load.

Any excessive wear decreases the cross-section of the metal at the ends of the links and so decreases the factor of safety of the chain. From the above we see that the result of overloading a chain is made evident by the elongation. In many shops, men are trained in the careful use of chains and are taught that only loads that do not stretch the chain are safe.

Some Easily Applied Methods of Inspecting Sling Chains

To detect elongation, the chain should be measured when new, before it is put into use and again measured at each inspection period. Either the overall length of the chain can be measured and recorded, or the chain can be measured off in 3-ft. sections, and marked off carefully by prick-punch marks.

It is recommended that chains in daily use and subjected to ordinary service should receive careful inspection about once in two or three weeks. If used for more severe or heavier duty they should be inspected more often. If chains are not used daily they may be inspected at such proportionately greater intervals as the experienced chain man may consider necessary.

Precautions to Take When Using Chain Slings

Don't overload a chain.

Don't apply a load to a chain suddenly.

Don't fasten chains over sharp corners or edges.

Don't cross a chain, twist it or put a kink in it.

Don't take chances; if a chain doesn't look safe or doesn't pass inspection, scrap it.

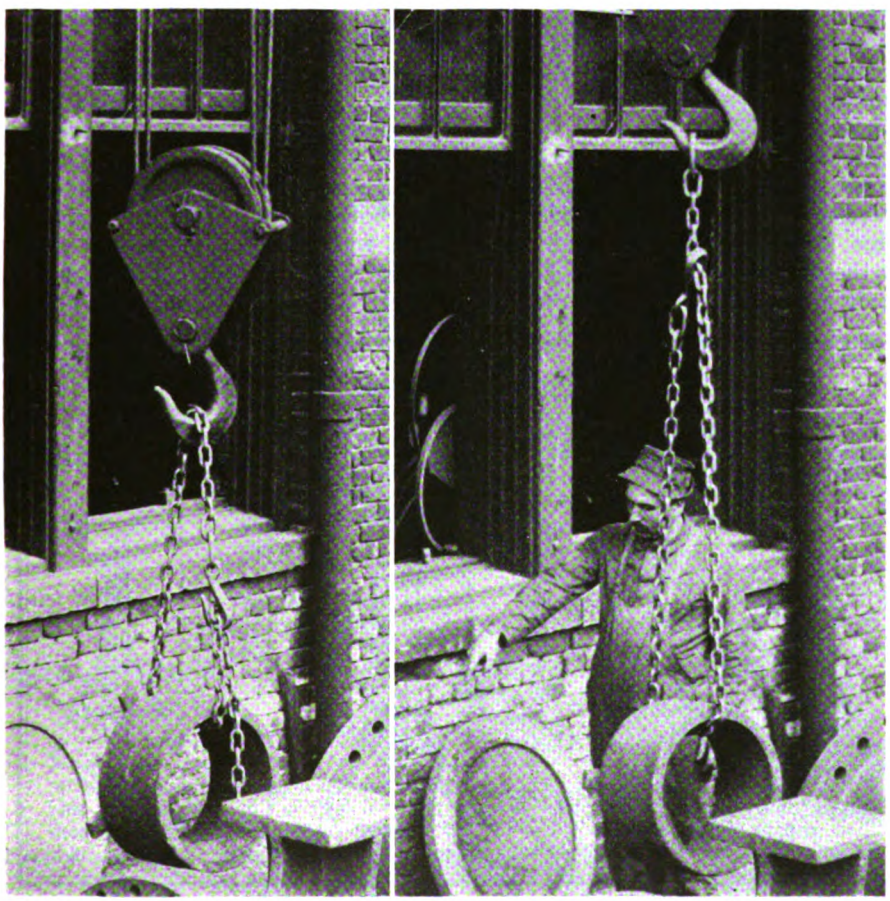
Don't forget constant and careful inspection.

Inspection consists in closely examining every link, hook and ring for defects. If any link or attachment shows a flaw, insecure weld, crack, fracture, or any other defect, the chain should be laid aside and marked unsafe. It should not be used again until the defective parts are taken out of the chain, and the chain is repaired. The chain should also be measured for elongation, having been measured or marked off when new, as described above. If any 3-ft. section has been found to be stretched considerably more than the remainder of the chain, that section, or still better, the whole chain should be condemned for that particular job.

Records should be kept of the results of inspections, and when they show that a succession of chains on a given job have all become considerably elongated, it is natural to infer that the service requires a chain with a higher factor of safety—in other words, a heavier chain. This system of periodic inspection has been found very effective in reducing chain failures. A chain that has been elongated on some particular job may still be safe to use on lighter service. Excessive elongation is the result of the careless use of the chain, and this should be corrected at once. If there is any appreciable wear at the ends of the links where they bottom, the chain should be considered unsafe, or the safe working load should be reduced until it is well within the safe working capacity for the weakened condition.

Some Points to Consider on Annealing Chains

Hoisting chains are usually subjected to severe usage and are, therefore, particularly liable to failure through fatigue, due to repeated shock or loading, and through overstrain due to overloading. Stretching of the chain due to overloading also tends to make the metal brittle. Annealing, when properly and carefully done, softens the metal sufficiently to relieve the internal strains, makes the chain less brittle, and allows it to stretch before breaking when overloaded. The sling chain hook should also be annealed with particular care, for when properly annealed, it will gradually yield and begin to straighten out, if overloaded, and thus give warning of possible danger. Chains and attachments should be inspected very carefully after annealing, as defects and flaws not visible before annealing may then show up. Many large foundries and railroad shops anneal



The right and the wrong methods of hooking up a single sling chain. The illustration at the left shows the correct method of using a single-sling chain to handle loads such as this. Here the sling is suspended from the middle of the burden hook and the grab hook is also properly fastened. In the illustration at the right, however, the ring of the chain is caught over the tip of the burden hook, even though it is too small to go onto the hook far enough to be safe. In such cases as this where the load is applied so far out on the tip of the hook an extra heavy load may straighten out the hook until the load may slip off. The hook is designed to carry the load down in the throat and not on the tip. Also, in this case, the grab hook is improperly fastened. These illustrations are used by courtesy of the National Safety Council, Chicago.

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their chains at regular intervals by competent workmen, who know how to secure the desired results.

There does not seem to be as yet a recognized standard method of annealing chains, as evidenced by the different methods and temperatures employed by the large users of chains, who consider periodic annealing of some value.

Many other important factors enter into the problem of the proper annealing of chains; however, in general, annealing consists in heating the chain to a uniform temperature of between 1,500 deg. F. and 1,600 deg. F., keeping it at this heat only long enough to heat the chain throughout, and allowing it to cool freely in air.

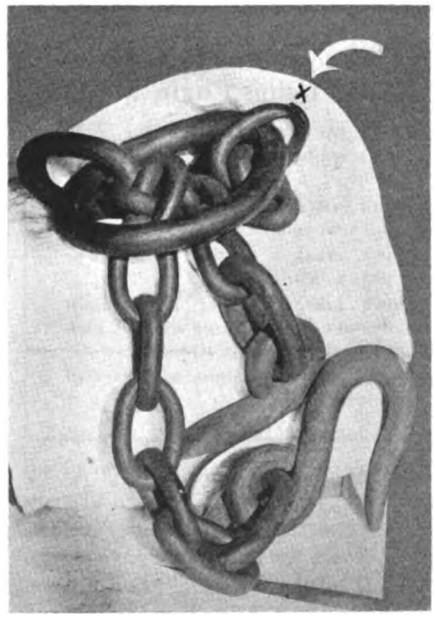
It should also be remembered that every annealing operation lowers the breaking strength of the chain, and hence decreases the safe working load. Annealing does not eliminate the minute cracks in the metal caused by repeated overloading; nor does annealing restore an elongated chain to its original length. Rather than recommend the annealing of chain, we emphasize the importance of preventing the overloading of chains. Annealing is merely a means of partially compensating for abuse of a chain.

Fixing Responsibility for Care of Sling Chains

In every shop some particular person should be held responsible for the selection of the sling chains used for hoisting, and for making suitable hitches about the loads. Experience will have taught him to be able to select the proper sling quickly and intelligently, and to attach the sling, or to hook on to the load in the best and safest way.

When the load to be lifted has sharp corners or edges, they should be protected where the chains run over them; otherwise the sling or load, or both, may be damaged. Thick pads of burlap or other soft material or, still better, wooden protective corner pieces, made by nailing two blocks of wood together to form an L-shaped block which fits on to the corner of the load, are used to prevent the sling from being abraded as well as the load from being damaged.

A double sling chain should be sufficiently long to leave considerable space between the top of the load and the point of suspension of the sling. This is to keep the angle between the legs of the sling as small as possible, usually under 75 deg. except in unavoidable cases. The fact is often disregarded that the greater the angle between the legs or branches of the sling, the greater the stress in the links under an equal load. How much this stress increases with each increase in the angles is given in the table at the top of page 224.



It is only by careful inspection that an unsafe link such as this is found. Here the link shows excessive wear where it "bottoms" on the ring; also it is beginning to crack. This link would probably break on the first heavy load applied. The remainder of the chain looks as though it were in good shape and would have considerable useful life in it if this link were replaced.

Hooks on sling chains are sometimes forced into place by striking them with some heavy implement. This practice should be prohibited, as the hooks may thereby be dangerously weakened. The hooks should not be used so as to carry a load on their point. Hooks are not designed for such service and, if so used, are very likely to open up or break. Sling chains generally have a ring to hook into, or else the hook grabs the chain; that is, the chain passes through the belly of the hook. The point of the hook should never be inserted into a link.

The accompanying table shows the sizes of single and double slings recommended for various loads. The sizes of double sling chains are based on the assumptions that the angle between the legs is not over 75 deg. and that approximately one-half the load is carried by each leg. If either or both these conditions are not fulfilled, a suitably heavier size of chain should be used. If the load is of such a nature that one leg carries considerably more than the other, care must be taken that the leg carrying most of the load is not overloaded. One leg or branch of the sling may carry an undue proportion if the load is not applied properly.

On chain hoists, where the chain passes over a wheel which has a rather small diameter, there is an excessive movement or rubbing of the links at the ends where they bottom. If the chain carries a heavy load, the wear at the point of bottoming may be excessive. This wear results in a reduced section at the ends of the links, and the factor of safety of the chain is therefore reduced. To prevent this wear, the diameter of a chain wheel should be about 24 times the size of the chain, and never under 12 times, if it can be avoided. There may occur conditions when it is inadvisable to increase the present size of a small wheel; in such cases the chain

Sizes of Sling Chains Recommended for Given Loads

Load Pounds	Single Sling Inches	Double Sling Inches	Load Pounds	Single Sling Inches	Double Sling Inches
1,125	1/4	...	22,400	1 1/8	7/8
1,700	5/16	1/4	28,800	1 1/4	1
2,700	3/8	5/16	34,500	1 3/8	1 1/8
3,450	7/16	3/8	40,800	1 1/2	1 1/4
4,325	1/2	3/8	46,100	1 5/8	1 1/4
5,525	9/16	7/16	52,500	1 3/4	1 3/8
6,925	5/8	1/2	58,500	1 7/8	1 1/2
8,550	11/16	9/16	66,000	2	1 5/8
10,150	3/4	5/8	74,400	...	1 5/8
12,250	13/16	11/16	84,000	...	1 3/4
14,000	7/8	3/4	93,600	...	1 7/8
18,600	1	13/16	107,000	...	2

NOTE: Sizes of double sling chains made from dredge chain are based on the assumption that the angle between the two legs is not over 75 deg. and that approximately one-half the load is carried by each leg. If these conditions are exceeded, a heavier size of chain should be used.

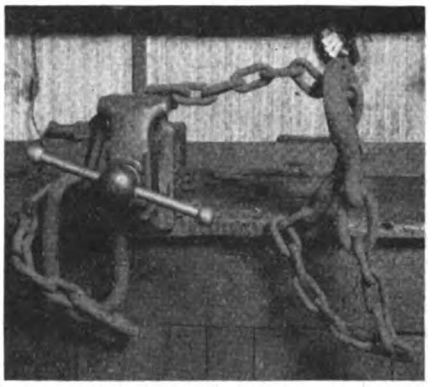
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should be replaced by a new one as soon as it shows any appreciable wear. The size of a chain is determined by the diameter of the metal used to form the link.

When a block or pocket-wheel chain has become stretched, due to overloading or to wear, the links no longer fit the wheel. The only remedy is to install a new chain. When a chain is removed from a wheel to be repaired, it is essential that the chain be replaced so that the links lie in the same plane as they did before being removed. Observance of this rule will add considerably to the life of the chain. By marking a few of the links before removing the chain from the wheel, this can be easily accomplished. Obviously the chain should not be twisted when replaced.

Keep chains clean and free from grit, which causes rapid wear at the ends where the links bottom. This wear can be decreased by oiling the bearing surfaces between the links. In fact, frequent oiling of the complete chain will not only prolong the life of the chain, but will also prevent rusting. However, oil should be used sparingly on hoisting chains operating in places where the air contains gritty or abrasive material. The oil will simply catch the dust and hold it.

Chains for hoisting or for slings, like any other kind of industrial equipment, must be handled properly to insure long life and satisfactory service. Of all the abuses, overloading is the most serious not only because of the damage to the chain but also because of the serious accidents which may result when an overstrained chain gives way. There is no telling where the load will drop.

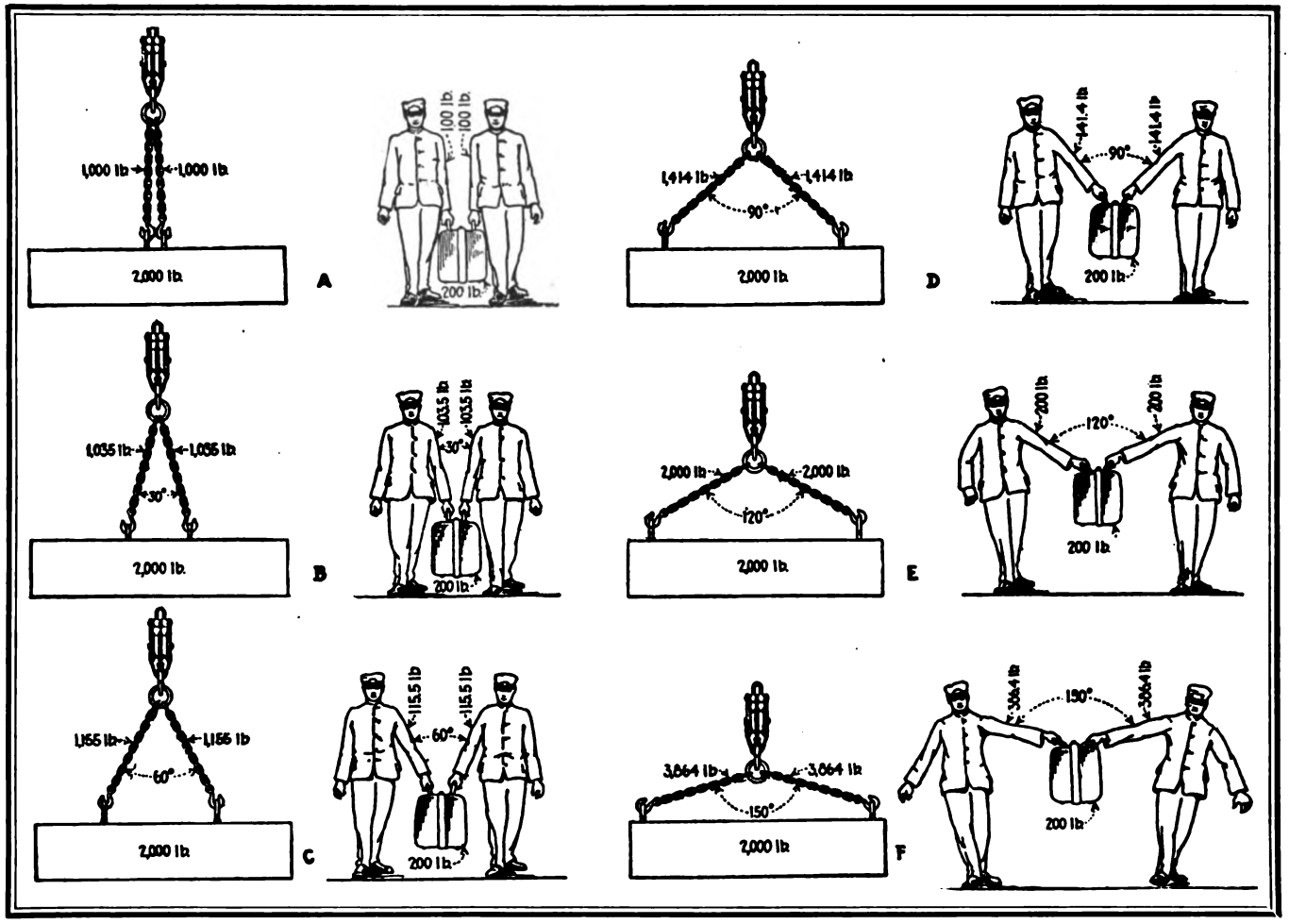


This chain has been permanently damaged by overloading.

Overloading chains until they stretch causes the links to lock so that the chain becomes stiff. This chain has been so heavily overloaded that the links are no longer pliable. The entire weight of the chain is supported by the seven horizontal links held in the vise. Other links below the hook in the illustration are also locked because of stretching. In this case the damage is largely confined to one branch of the chain. This may be due to the fact that the entire load was at times lifted by one chain instead of using the double sling.

Although these drawings do not explain "Why," they show how the branches of a double-sling chain may be overloaded, and in a manner which can be easily understood.

The load on the two chains and the strain on the arms of the two men carrying the handbag are similar. It will be noticed that as the arms of the two men are practically vertical each carries approximately half the weight. However, as the angle between them increases, the pull or strain on their arms also increases. As long as this angle is of moderate size the increase is not important because a chain has a factor of safety which will take care of the slight increase in load. However, at 120 deg. the pull on each chain equals the total load. The pull is excessive at 170 deg., where each of the branches takes a stress approximately 5¾ times the original load. Ordinarily, the factor of safety in a chain is somewhere between three and four times its safe working load. The angle between the branches should never be over 120 deg., as even at that point the chain is under a stress of twice as much as the weight of the load. An accompanying table shows the safe working load of chains at various angles. An angle of 75 deg. is the maximum recommended.



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Here Are the Details of a

Fuse Color Scheme That Prevents Misuse of Fuses

Together With an Analysis of the Causes of Improper Use and the Methods That Can Be Used to Correct the Trouble

By CHARLES R. HEPNER
Chief Electrician, Willard Storage Battery Co., Cleveland, Ohio

"INVESTIGATION showed that our fuse troubles were due to our own carelessness (and we are perfectly frank in calling it carelessness) and that they could be attributed to the following causes: (1) Fuses with the paper sticker off; (2) fuses in the wrong bin although properly labeled; (3) fuses refilled to a capacity other than that indicated by the sticker; (4) fuses refilled improperly; (5) fuses blown but put into the stock bins; and (6) over-fused apparatus."

In these words Mr. Hepner tells what was disclosed by a careful study of the methods of handling and using fuses, in an endeavor to eliminate the troubles which were being experienced. In the accompanying article he analyzes the causes and results of the conditions which were found and explains the plan that he used to overcome them in the plants of the Peerless Motor Car Company and the Willard Storage Battery Company.

ABOUT seven or eight years ago, after several years spent in maintaining the equipment in a large plant where the aim of the *Electrical Department* was to keep the motor outages down to the lowest possible point, I became convinced that a great deal of our trouble was of our own making. As proof that my diagnosis was correct, we finally arrived at the point where we carried the plant along for several years with no motor outages over eight minutes in duration.

A great deal of this successful operation I attribute to the fact that we decided, after considerable investigation and thought, that most of our troubles were due to improper handling and misuse of our best friend, our safety valve, the fuse. I found that there were many contributing factors to this improper handling and misuse of the fuse.

As is generally the case in most shops, we kept our fuses in drawers or bins, the various sizes being kept in regular order. For instance, the 10, 15, 20, 25, and 30-amp. N. E. C. cartridge fuses were kept in five bins which were placed in a row side by side. The 60-amp. cartridge fuses refilled for various ratings were kept nearby.

Our investigation showed that our fuse troubles were due to our own carelessness (and we are perfectly frank in calling it carelessness) and that they could be attributed to the following causes:

(1) Fuses with the paper sticker off.
(2) Fuses in the wrong bin, although properly labeled.
(3) Fuses refilled to a capacity other than that indicated by the sticker.
(4) Fuses refilled improperly.
(5) Fuses blown but put into the stock bins.
(6) Overfused apparatus.

I am sure that you will agree with me in using the term carelessness after you give these remarks a little consideration. For instance it may not necessarily be due to carelessness that a sticker is lost from a cartridge, but it is carelessness, pure and simple, to take it for granted that a fuse is a 10-amp. fuse just because it is in the 10-amp. fuse bin. Again, it is carelessness when a blown fuse is accidentally returned to the stock bin with some good fuses, because the maintenance man forgot to test them out.

Let us consider in detail some of the troubles that our investigation showed were causing the misuse of fuses.

(1) *Fuses with the Paper Sticker Off.*—There are quite a few things that can and do happen because our friend the fuse has lost his identity. One man will pick up the fuse and on seeing no identification mark will toss it into the 30-amp. bin with the remark, "Well, if it isn't a 30 it will blow and the motor will be protected anyway."

But, he doesn't stop to think that when that fuse does blow because it is not a 30 and is inserted where a 30 ought to be, it means much more than the price of a fuse. It means a motor down longer than necessary; it means one or more men out of work longer than necessary; it means that production is held up longer than necessary; it means friction between the production and the maintenance departments; it means loss of profit to the firm; and it means a loss of bonus to the men. So you see, it means a great deal more than just the price of a fuse. And all because a sticker was lost from a fuse cartridge.

Another man will look at the fuse without a sticker and he will say, "I'll put it in the 10-amp. bin, for if it is heavier it will carry the load

Color Scheme for Indicating Size of Fuse

Size of Cartridge	Ampere Rating of Fuse				
	Black	White	Yellow	Blue	Green
1 to 30 amp.	10	15	20	25	30
35 to 60 amp.	35	40	45	50	60
65 to 100 amp.	65	75	80	90	100
110 to 200 amp.	110	125	150	175	200
225 to 400 amp.	225	250	300	350	400
450 to 600 amp.	450	500	525	550	600

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without blowing." But he doesn't realize that if it happens to be a 30-amp. fuse that is inserted where a 10-amp. fuse ought to be, it will probably result in a burned-out piece of apparatus. This in turn means more expense and loss than in the previous case, for it entails changing motors and possibly rewinding one. It takes time and money to replace and repair a burned-out motor.

If a careful man happens to get the fuse with the sticker off he will take it apart and find out for sure just what size it is; but this again is a waste of time.

(2) Fuses Properly Labeled but in Wrong Bins.—It happens frequently that a fuse will get over the partition into the wrong bin. For instance, when a man is putting a lot of 15-amp. fuses into the correct bin, one of them may accidentally fall over into the 20-amp. bin and the maintenance man will take it to be a 20 because it is in the 20-amp. bin. Or if it falls into the 10-amp. bin it will be mistaken for a 10. So you see the same conditions arise as in the case where the sticker is lost from the cartridge.

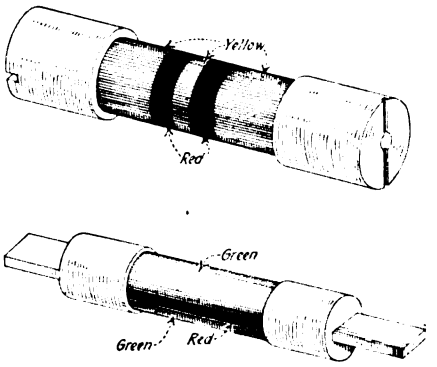
(3) Fuses Refilled to a Rating Other Than Indicated by the Sticker.—Of course, it is to be expected that when a fuse is refilled to a rating other than indicated by the sticker, the man refilling it will mark the rating on the case; but sometimes we all forget. So again we have the same conditions as when the sticker is lost, only in this case we are misled by the marking.

(4) Fuses Refilled Improperly.—Unless care was exercised in choosing the man to refill the fuses, we found that the refills would be put into a cartridge without cleaning up the contacts; or the fastening screws would be left loose; or the refills would be twisted and partly torn. These troubles can be overcome only by selecting competent and trustworthy men to do the refilling.

(5) Blown Fuses Put in Stock Bins.—Our investigation showed that frequently the trouble shooter would, when returning fuses to the bins, put a burned-out fuse in the bins along with the good ones. This necessitated testing each fuse when it was taken out of the bin. This is, of course, a waste of time, as all fuses in the bins should be O. K.

(6) Apparatus Overfused.—We found also that the custom or habit of the ordinary electrician, when removing a burned-out fuse, is to put in one just a little bit heavier. This is done because he thinks that the motor is carrying a load up to the capacity of the fuse and he doesn't want any more fuses to blow in this motor line. This practice results in the circuits gradually becoming overfused, so that they are no longer protected by the fuses.

In order to overcome the troubles brought to light by our investigation, we decided to adopt the following scheme: (1) All fuses to be refilled and put in stock by one responsible man; (2) records kept of all fuse outages; (3) installation of a color scheme for fuses.



Scheme used for indicating underfusing or overfusing of a cartridge.

If a fuse is refilled with links below the rating of the cartridge, lengthwise red stripes are painted on the cartridge, as shown in the top illustration. Each stripe indicates that the fuse is one size smaller than that given for the main color of the fuse as indicated in the accompanying table. If larger than rated refills are used in a cartridge, red rings are painted on it, as shown in the bottom illustration. Each ring indicates one size larger than the rating for that color as shown in the table. For instance, a 200-amp. cartridge having the barrel painted yellow with one red ring around it, would indicate that the fuse had refills in it to make it blow at 300 amp. instead of 200 amp., which would be the case if no red ring were painted around the barrel.

One man on whom we could rely was delegated to inspect all fuses on hand, to do all refilling, and to have charge of the painting of the cases.

A survey of our plant was then made and the various apparatus was carefully fused according to its demand. A record of this was made for future reference. Each time a fuse is replaced for any reason, a report is made showing the rating of the fuse taken out, the rating of the fuse put in, and the cause of the change. If the rating of the fuse was changed, a satisfactory reason must be given. This stopped the practice of putting in fuses of higher rating without adequate reason therefor.

To overcome the troubles due to the first three causes listed before we decided upon a color scheme for the fuses. Five colors—black, white, yellow, blue and green—were chosen for the base colors, with red for a danger sign.

For instance, we took a 10-amp. cartridge, scraped the paper sticker off and painted the barrel black. We also painted the 10-amp. fuse bin black. The 15-amp. cartridge and bin were painted white, and so on.

A light blue must be used to keep this color from getting confused with the black when the blue gets dirty.

The accompanying table shows the sizes we chose to use and as they cover the range of sizes pretty thoroughly, we have no trouble in properly distinguishing with the five base colors, the fuses which it is necessary to keep on hand. A great many times it is convenient to underfuse a cartridge. For instance, we may have a 200-amp. fuse block and want only a 100-amp. fuse in the circuit. To provide for this emergency, we take a green 200-amp. cartridge and refill it for 100 amp. A red stripe is then painted along the cartridge from one end to the other. If this same fuse were refilled for 60 amp., two stripes would be painted on the cartridge and the cartridge would be placed in the fuse block with the stripes facing out, so that it could be seen at a glance that the fuse was underloaded. One stripe is used for each variation in size of cartridge. Reference to the accompanying table will show that a 200-amp. fuse in a 200-amp. size case would be painted green.

If a red stripe is painted on the green case, it indicates that the fuse link in the 200-amp. case is the next size smaller than that shown in the green column of the table; that is, it is a 100-amp. link. If there are two red stripes painted on the green case, it would indicate that the fuse link was two sizes smaller than the 200-amp. size given in the green column; that is, it would be a 60-amp. link. This scheme of striping is shown in the accompanying illustration.

Sometimes it is necessary to overfuse cartridges and in this case a red stripe or ring is painted around the center of the cartridge. One ring is used for each variation in size of cartridge. For instance, if we have a 60-amp. fuse block and want to put in 150-amp. fuses, we would take cartridges painted

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MACHINE WINDING of fractional horsepower, universal and other small armatures, as contrasted with hand winding, presents important advantages in the way of saving in time, uniformity of winding and lessened danger of short-circuits and other defects or injury caused by pounding. In this article Mr. Chapman describes the procedure involved in winding small armatures by machine and gives some helpful suggestions on various phases of the work, including the connecting of the leads to the commutator.

Some Practical Pointers on

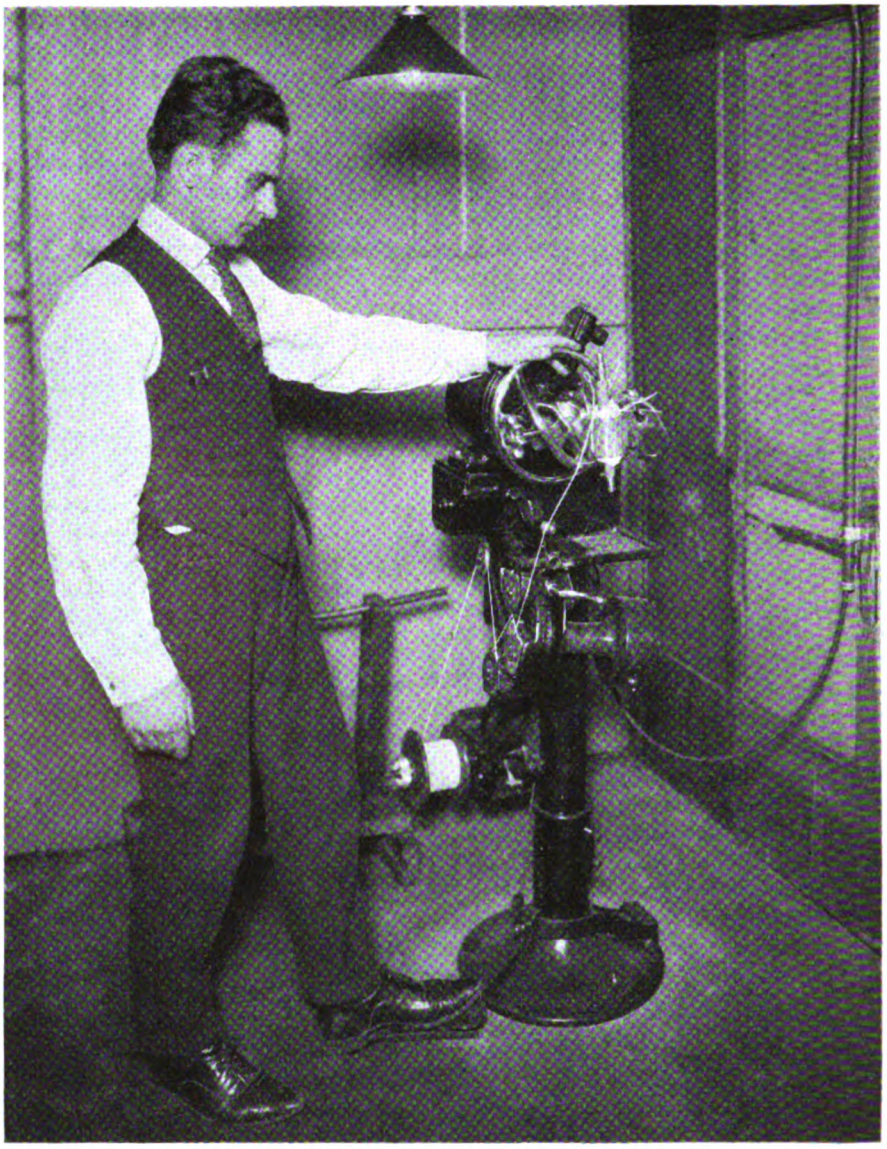
Winding Armatures by Machine

Together with Methods of Insulating the Core and Connecting Leads to the Commutator

By P. E. CHAPMAN
President, P. E. Chapman Electrical Works, St. Louis, Mo.

PRACTICALLY all small armatures coming within the classes known as fractional horsepower, fan, and universal, as well as some automobile generator armatures, are best wound by machine. Machine windings have the advantages that they are more nearly parallel, take up less space, are more free from short-circuits and other defects, and may be put on many times faster than by hand. In view of the very large number of small motors that are in use, a brief description of the principles and methods of operating armature winding machines may be interesting.

There are two distinct types of armature winding machines. The first is a fixed-size machine which will take only one size of armature, although it will handle any of the various windings usually put on the same armature core, for example, 32-, 110- or 220-volt windings. Such machines are, of course, suitable only for factories where the production of one size of armature is large. Machines of this type are usually double-ended; that is, they have a headstock and tailstock.



The operator of this armature winding machine has stopped it with one of the coils about half wound on. The turn-counting device may be seen just above his left hand. As will be noticed, the driving motor is controlled by the foot lever. The hand wheel, on which the operator's left hand is resting, serves as a brake and is used for putting on the last one or two turns.

Although there are several different makes of adjustable-type machines which can be used for winding the classes of armatures mentioned above, the descriptions and directions will apply in a general way to all of these machines.

Contrary to what might be expected, armature winding machines are of comparatively simple construction. For example, the Chapman bipolar drum armature winding machine, which is representative of this class of machines, consists essentially of a winding head which is mounted directly on the shaft of the driving motor. As will be seen from some of the illustrations, there are two jaws which are adjustable and serve to hold the armature core firmly while the coils are being wound on. Curved wings guide the wire into the slots. A counter mounted at the side of the driving motor keeps track of the number of turns wound on.

The wire, which is wound on spools, passes through a tension device which maintains the tension uniform and at the desired value, and permits quick starting and stopping without stretching the wire or allowing it to keep on unwinding after the machine is stopped. A general view of this machine is shown in the illustration at the beginning of this article.

Before an armature is stripped for rewinding, certain data should be taken and kept for reference, unless these data are already on file. The data required for rewinding small armatures are similar to that needed when working on large armatures

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and should include the following items:

(1) Nameplate rating of the motor or generator.
(2) Number of turns of wire per coil.
(3) Number of coils per slot, or bundle.
(4) Size of wire.
(5) Kind of covering, or insulation.
(6) Span of the coil; that is, number of teeth a coil surrounds, or the number of slots per coil, which is usually counted as one more than the number of teeth enclosed.

It is advisable to take the following data also:

(1) Total number of armature slots.
(2) Total number of sections in the commutator.
(3) Position of the commutator with reference to some fixed point, as the shoulder of the shaft.
(4) Weight of wire.

Some good pointers on stripping armatures can be obtained from an article, "Ten Men Can Rewind 2,000 Armatures per Month" in the March, 1922, issue of INDUSTRIAL ENGINEER. It is always wise when stripping an armature to preserve the fiber heads, if possible.

Before rewinding it is, of course, necessary to insulate the core, which operation was covered in considerable detail in the article, "How to Wind Fractional Horsepower D. C. Motors," in the January, 1922, issue of INDUSTRIAL ENGINEER. I consider the continuous strip method of insulating to be the best. This is carried out by taking a long strip of some form of tough paper and fitting it either with or without the aid of pegs around the inside of the slots and over the teeth all of the way around the armature. A good, tough paper, such as was originally known as Leatheroid, and which can now be had under many other names, is the best. Papers of this character will hold their shape and eliminate the necessity of tying or sticking the insulation in the slots.

For strictly production work where the slots are not filled too full, cutting the slot insulation to the exact size and if necessary forming it in a hot die, is by all means the fastest method of insulating the slots. The grain of the paper should always run around the slot.

The method, which is sometimes used, of cutting short pieces of insulation and allowing the edges to stick out of the slots, is not to be recommended, as these edges require too much attention.

Wire with any kind of covering can be wound on by machine, but armatures should never be wound with anything but double-covered wire, as they will not stand up well in service. Wire with single insulation is only suitable for winding magnet and field coils, and it is not suitable even for these purposes when the wire is fairly large, say No. 12 B. & S., and coarser.

Enameled wires may, in general, be considered as equivalent to single-covered wires and should never be used, without another covering of some kind, for winding armatures. When rewinding an armature which was formerly wound with plain enameled wire, it is better to sacrifice somewhere else on the motor and use a double-covered wire on the armature.

So far as armature work is concerned, double-covered wires may be classified in the order of their heat-resisting and mechanically desirable properties, and their range of usefulness for random windings, placed directly on the armature core, about as follows:

TYPES OF COVERING	USUAL SIZES
Double cotton	Nos. 12 to 28 or 30
Cotton and enamel	Nos. 12 to 28 or 30
Silk and enamel	No. 28 and finer
Double cotton and enamel	No. 20 and coarser
Triple cotton	No. 20 and coarser
Silk, not used in sizes above	No. 20

Silk-covered wires are the most delicate, stand less heat and burn out quickest by slow roasting, but take the least room. They are highly useful where a large number of turns of fine sizes are required, and when cotton-covered wire would require an excessive volume in the slots. Both silk and silk-covered, enameled wires should by all means be avoided for armature work, in sizes coarser than about No. 27 or 28 B. & S. gage. Above this size they are very delicate and have to be insulated between coils and sometimes between layers.

Armatures wound with No. 20 and smaller wire are usually wound "random"; that is, not in layers and without auxiliary insulation between coils, as there is enough "cushioning" in these sizes to prevent me-

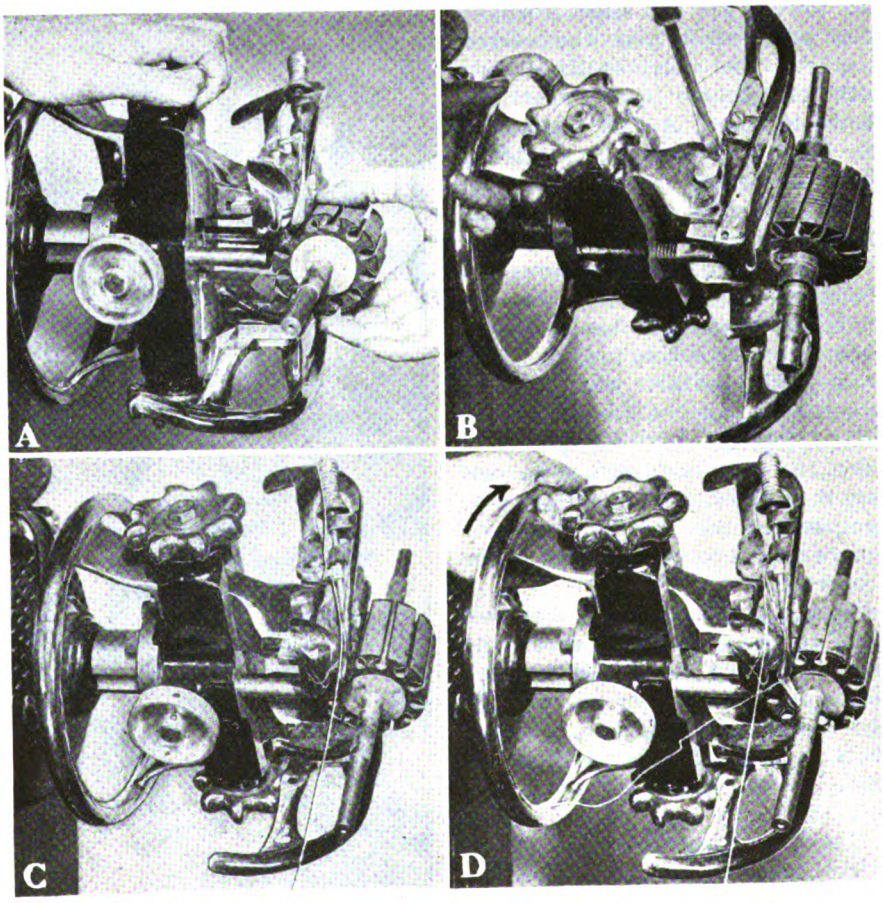


Fig. 1. These illustrations show how the core is placed in the jaws of the machine and the first coil wound on.

As shown in *A*, the core is firmly held by clamping the jaws on two slots which will give the proper span for the coils. When cores with skewed slots are being wound, as in *B*, the jaws must be adjusted to match the angle of the slots. In *C*, the wire has been given a turn around the snubbing pin in order to hold it against the winding tension. *D* shows an armature with more than one coil per slot. The first lead has been removed from the snubbing pin and the second coil will then be wound on.

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chanical shorts. Modern baking varnishes will give the coils sufficient dielectric strength to permit satisfactory service at voltages up to 220 volts.

Armatures that have to be wound with wire coarser than No. 20 B. & S. gage should have insulation inserted between the coils, or be wound with triple-covered wires. Or they may be wound in layers, or wound on forms and assembled with auxiliary insulation between the coils on the heads. Auxiliary insulation is required for mechanical reasons on all small armatures wound with coarse wire, No. 20 and larger. This is particularly true of cotton-covered and enameled wires, as they are very deceptive and apparently sound armatures will sometimes break down in a few weeks. Instances are known where 60 per cent of the entire output of a shop has broken down in three months for lack of this insulation between coils on the heads.

Procedure When Using Armature Winding Machine

After the cores have been properly prepared and the slot insulation has been put in place, the next operation is winding the core. When placing the core in the winding machine, point the commutator end of the core toward you and select a pair of slots which will give the correct span for the coils, spotting them with the thumb and fingers, as shown in Fig. 1 *A*. Set the core in the jaws with their edges aligned. The jaws should overhang the edge of the slot about 0.005 to 0.010 in., or the thickness of a business card.

When setting open-slot cores, set about one-half the width of the slot under the jaws; that is, allow about one-half of the slot to project. This is especially desirable when the core is small in diameter. In order that this adjustment may be readily kept when the core is turned, or a new core is inserted, move the depth stop against the core. This will both square up the core and hold it at the proper depth.

Some armatures have skewed slots, and many that are apparently straight are a little off. When such cores are encountered it will be necessary to compensate for the twist by adjusting the winding machine jaws to match the slot angle, as in Fig. 1 *B*.

Machine armature winding requires considerable tension on the wire, more than is needed for winding plain coils, as the wire is pulled into place rather than pushed or pounded, as in hand winding. The best all-around tension is about 1⅛ lb. per 100 circ. mils of wire area. To illustrate, suppose we are winding an armature with No. 27 B. & S. gage wire. This size wire has an area of 202 circ. mils and would, therefore, have 2¼ lb. tension put on it. This tension will not stretch the wire, but will pull it into place nicely. Armatures are occasionally encountered which require that the wire be stretched in winding, but it is bad practice to do this.

In any case the tension required is so high that some form of tension device is necessary. It is almost impossible to get this tension by hand and even if it were possible to obtain it, the tension would not be uniform and the speed of operation would have to be reduced considerably, while a good deal of extra pounding would be required.

A successful reel holder and tension device will require that the inertia of the spool at starting, which is frequently sufficient to break the wire, be compensated for. It is necessary that the momentum at stopping be overcome and the slack taken up. In the case of No. 28 B. & S. gage and larger wire, auxiliary tension must be applied to the wire for it is not safe to put so much tension on the spool, as the delivering turn will frequently cut down into the remaining wire and snarl up. This auxiliary tension should be automatically controlled to compensate for the varying drag of the spool itself.

Whatever means are employed for adjusting the tension, the value of the latter may be ascertained by a spring scale, if desired. A good rule-of-thumb is to adjust or increase the tension until you can feel the wire stretch slightly, and then release it until there is no apparent stretch. This will give approximately the correct tension. If the tension device of the winding ma-

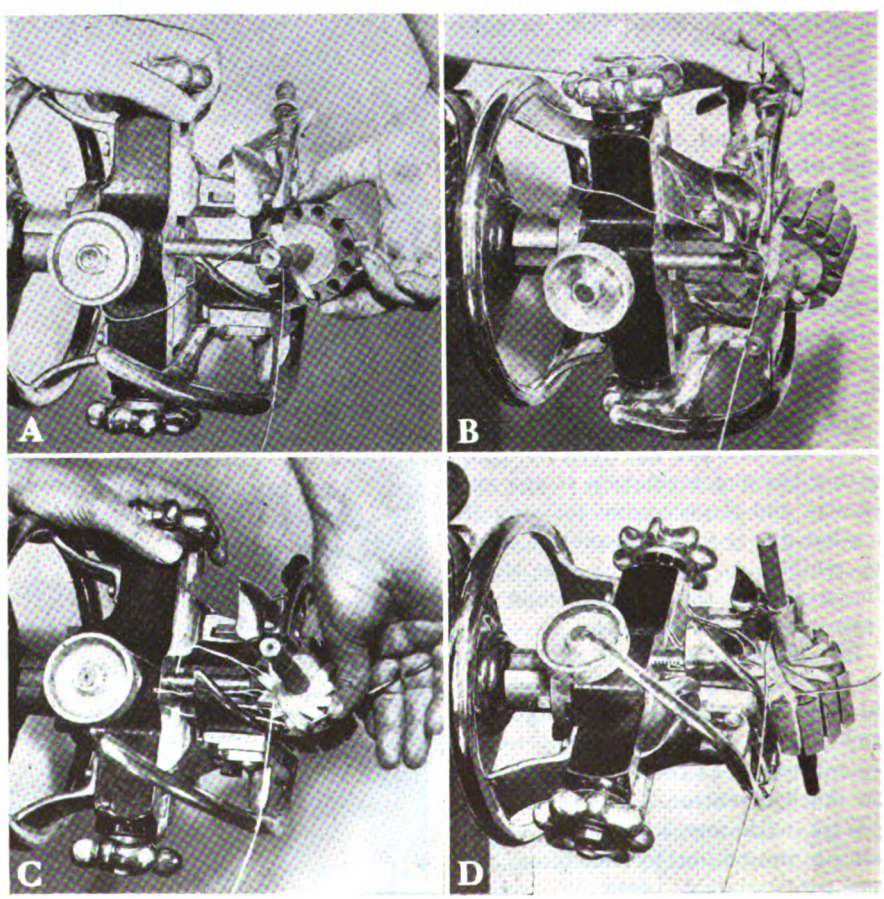


Fig. 2. After each coil is wound on, the core must be turned and the leads brought out.

In *A* the jaws of the machine have been released and the core turned one slot to the left. Most small, bipolar armatures are wound in this way. When the leads are formed by hand the core may be rotated the other way, if desired. *B* shows how the leads may be twisted by rolling a small handle between the thumb and forefinger. When the leads are short or the wire coarse, twisting is neither necessary nor desirable. *C*, a little hook may be used to advantage in pulling the leads out. The first end should be pulled to the right and the other leads kept to the left, as shown in *D*.

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chine is not automatic, it will be necessary to give the wire considerably less tension and then make up the difference by hand, or by pounding the coils, which is objectionable.

Old hand winders give the wire that lies on the surface of an armature a negative curve or "set," in order to make it lie down snugly at the center of the core. If this is not done, the wire will stick up, or belly outward. This negative curve or set is imparted to the wire in the Chapman machine by passing the wire under and around a roller which is small enough to give the necessary curve and is mounted on a stiff spring, to aid in taking up the irregularities in the pull on the wire. The wings and the curves of the jaws have been proportioned to preserve this curve or set in the wire, so that it will lie down tight in the bottom of the slot. This is accomplished by shaping the guides so that they do not touch the part of the wire that goes into the slots.

Coming back to the winding operations, after the wire has been fed through the tension device, snub it by giving it a turn around the snubbing pin, as in Fig. 1 *C*. The excess wire may then be broken off by giving it a jerk, which will make the main portion hold against the winding tension.

The exact number of turns required may then be wound on. If there is more than one coil per slot, disengage the first lead from the pin and wind the second coil, as shown in Fig. 1 *D*.

After the lead is disengaged index or turn the core one slot to the left, Fig. 2 *A*. Ninety per cent of the bipolar armatures made in this country are wound in this manner and will turn in the right direction when assembled in their fields. The other 10 per cent should have the field connections or brush leads reversed. If the leads are formed by hand the cores may, of course, be rotated the other way.

If the leads are long and the wire is fine twisting is sometimes desirable. In the Chapman machine this may be done by rolling the handle under the thumb, as in Fig. 2 *B*. If the leads are short or the wire is coarse, twisting is unnecessary, or even detrimental. A very good method of securing the lead wire in the slot is to advance the winding wire into the empty slot before indexing, or turning the core.

When you are ready to finish filling the first slot, watch out for the leads. The first end should be pulled to the right. This may be done with the fingers or with a little hook, which is faster. The method of using a hook is shown in Fig. 2 *C*. The other leads should be kept to the left, as in Fig. 2 *D*. Another way to get the first and succeeding leads out is to remove the core from the machine, when it is released for turning. Pull the lead to the right, with the left hand, and replace. This requires only one motion of each hand and may be found even better than the use of the hook. By pulling the first end out at this time it will meet the last one at the finish and close up perfectly.

The procedure for winding the other coils is the same as outlined above, and should be repeated until all of the slots are full. When the last coil is in, cut the wire and twist the final end with the first end. If the first end was pulled out at the proper point, as explained above, they will match up perfectly.

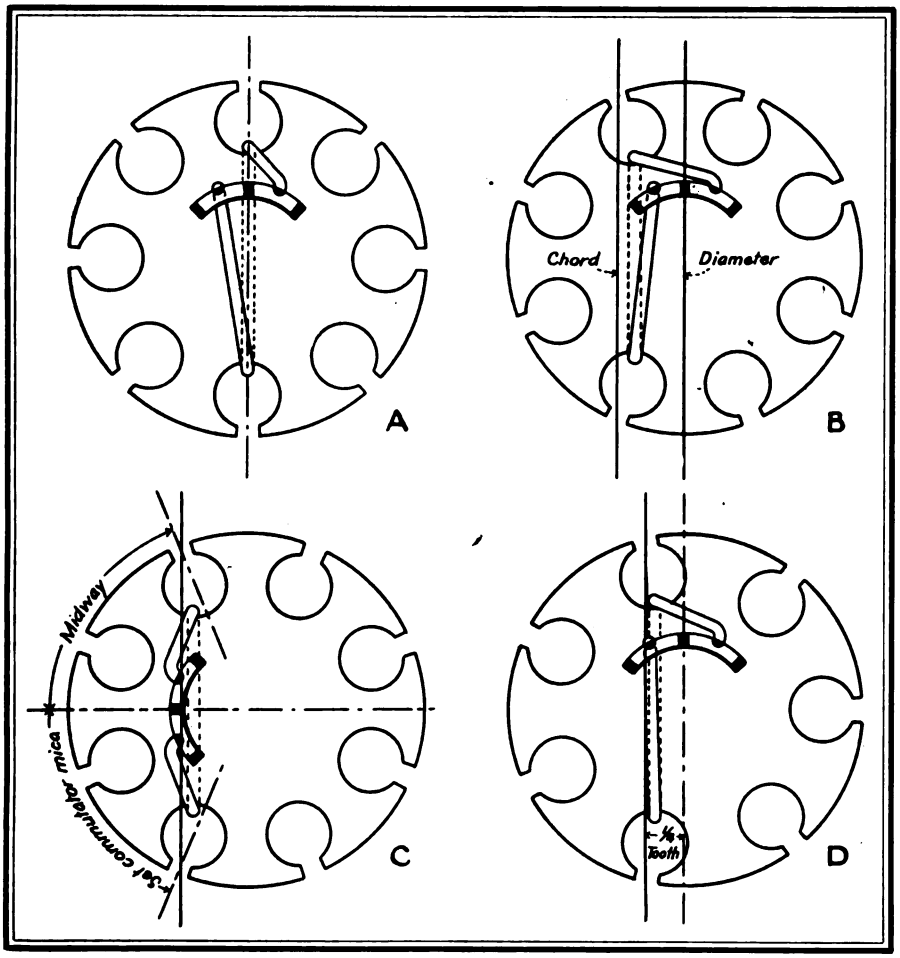
One point which it may be well to mention in connection with winding coils is that you should not make splices in a coil. If necessary unwind until the two ends come out at a lead.

After the rewound core is removed from the machine it will be necessary to fasten the wire in the slots. In the case of any armatures which have been wound with small wire, this may be done by tucking the ends of the slot insulation under the teeth, or by driving pegs in on top of the coils.

After an armature is wound the next step is to connect the leads to

Fig. 3. Diametrical or chord windings are used on small, bipolar armatures.

A shows the diametrical winding, in which the two sides of the coils are placed in slots located on a diameter or line passing through the center of the core, connected straight out, for brushes between the poles. A chord winding is shown in *B*. It will be noticed that the two sides of the coils lie in slots which are on a chord, or line parallel to the diameter of the core. The winding in *B* is shown connected straight out, when there is an even number of teeth in the core. The coil is displaced one tooth off the diameter, while the mica between the segments to which the coil is connected is displaced one-half tooth. *C* shows a chord winding connected for 90-deg. lead. A chord winding connected straight out when there is an odd number of teeth in the core, is shown in *D*. In this case the coil is displaced one-half tooth off the diameter, while the mica between the segments to which the coil connects is displaced one-fourth of a tooth.



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the commutator. Inasmuch as this is an operation in which mistakes easily can be, and oftentimes are, made, it may be worth while to cover the ground in some detail.

How Leads Should Be Connected to Commutator

When connecting the leads to the commutator be very careful that no pulling tension is put on the leads, either by drawing them tight and soldering them, or by subsequent hooding or banding. If they are soldered under tension they will break off at the commutator after a few hours' or days' run, without any apparent cause. When soldering very fine wires I recommend the use of rosin as a flux; this may be dissolved in alcohol and is non-corrosive.

On the bipolar armatures there are two general types of windings, commonly known as diametrical and chord. In the former type of winding the two sides of the coils are placed in slots located on any line passing through the center of the core and through the center of the slots. A diametrical winding is illustrated in Fig. 3 *A*.

If the commutator is connected up without lead, connecting this type of winding is very simple, as it is only necessary to remember that *the mica between any two segments corresponds to the center of the coil that is connected between the two segments.* In other words, for a straight-out winding, the mica should be directly in line with the average center of the slot. The term "average center of the slot" is used because in skewed armatures the slot at the end of the core is not the average center. The mica should, in this case, be set in line with the center of the slot at the center of the core. If the commutator has a lead, that is, if the brushes are not placed between the pole tips, the procedure must be modified by moving the commutator the amount of this lead, using the points mentioned as a measuring point. This will, of course, place the commutator mica for 90-deg. leads directly in the middle of the coil.

The chord or second type of winding is the prevalent type, or at least very common, on small armatures. In this winding the two sides of the coils lie in two slots which are not on a diameter, but on a chord, that is, a line passing through the center of the two slots in which a coil is placed, but not passing through the center of the armature. A winding of this type is shown in Fig. 3 *B*. In this case, the above rule does not apply. The reader should remember that a chord-wound coil will behave, so far as commutation is concerned, just the same as though it were on a diameter which is parallel to the chord on which the coil is wound.

It follows, then, that the mica corresponding to the coil in question must not be placed opposite to the average center of the slots in chord-wound armatures, but on a diameter paralleling that chord. In other words, as the ordinary chord winding is one tooth off the diameter, the mica will have to be placed one-half tooth away from the slot which holds the coil, for a straight-out connection. Fig. 3 *B* shows a straight-out connection, the brushes being placed between the poles, for a chord winding when there is an even number of teeth in the core. For a 90-deg. lead, the mica will be placed directly opposite the middle of the coil, as in Fig. 3 *C*.

If there is an odd number of teeth in an armature, and the chord is only one-half tooth off the diameter, the commutator mica will be placed only one-fourth tooth away from the coil, and so on, as shown in Fig. 3 *D*. An easy rule to remember is: *The mica of the commutator should be moved away from its coil one-half of the displacement of the coil from a diametrical position.*

The preceding explanations have been made on the assumption that there is only one section of the commutator and one section of winding per slot in the armature. When there is more than one section of winding per slot in the armature, the point of the commutator which corresponds to the middle of the coils in a slot is the point to which the measuring should be done. For example, if there are two sections, it is the segment connected to the middle lead. If there are three sections, the middle mica between the middle leads is the measuring point. If there are four sections, the middle lead is again the measuring point. Again, if there are two slots in the core per section of the commutator, the mica is again the measuring point. In all cases measure from the average center of the slot.

Split chord windings, windings in which one side of the coil is placed in two slots, are connected straight out; that is, with the mica opposite the average center of the slot which holds the full half of the coil. If the commutator has a lead, measure the angle from the point specified. This type of winding ordinarily has little in its favor and should be avoided if possible.

If these simple rules are mastered they will solve the problem of connecting any type of armature, including freak types, that I have ever heard of. These rules apply regardless of whether the commutator has many or few sections.

If the leads are incorrectly connected trouble will show up principally in the form of sparking at the brushes and irregularity in the torque of the armature, from tooth to tooth. The armature will tend to hang or stick at every tooth. The torque of the motor will be less than it should and, if the lead is 90 deg. off the motor will not pull at all. In any case the current consumption will be high and the efficiency low. If the lead is backward, that is, if the neutral is carried back under the brushes, the motor may flash over.

In the case of a shunt- or compound-wound motor the speed will, or may, increase and the motor may try to run away. A series motor will run at reduced speed, when loaded, and the armature and fields will get hot.

The only remedy is to check the lead connections and make sure that they are correct.

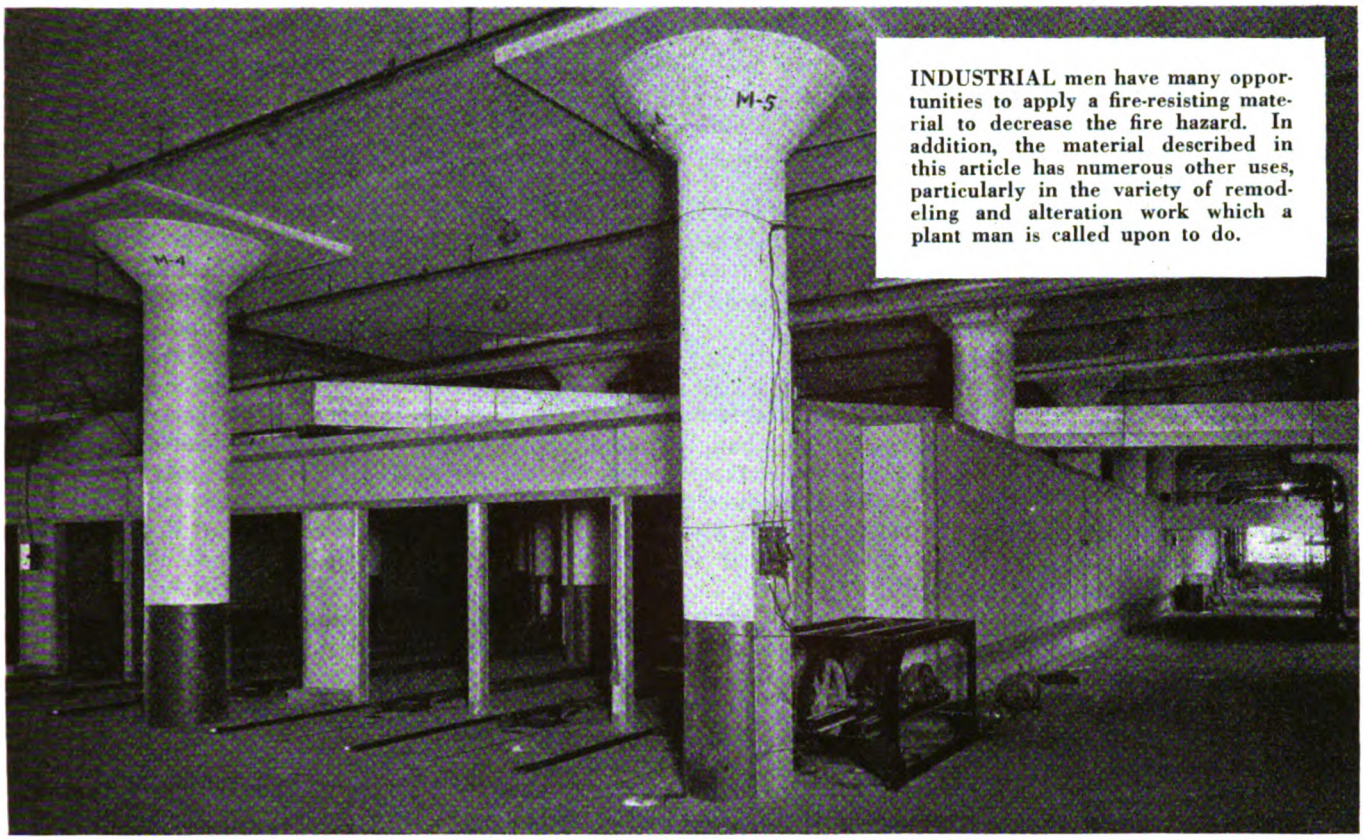
Thorough Impregnation in Varnish Necessary for Good Service

Before varnishing an armature it should be tested for balance and if it is found to be out, the heavy side should be placed up to drain and bake. In this way the varnish, which will naturally be heavier on the light side, will tend to correct the unbalance. After baking the armature should, of course, be again tested and balanced.

Armatures should be thoroughly impregnated by immersion in a good baking varnish, and baked in accordance with the directions of the varnish manufacturer. The reason why the modern small armature, with full potential across it and no auxiliary insulation between coils, stands up so well in service is largely because of the wonderful insulating qualities of the modern baking varnish. However, varnish must penetrate the armature completely or the

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INDUSTRIAL men have many opportunities to apply a fire-resisting material to decrease the fire hazard. In addition, the material described in this article has numerous other uses, particularly in the variety of remodeling and alteration work which a plant man is called upon to do.

Non-combustible wallboard, built up on wooden studding is used to line and cover this body kiln in a St. Louis, Mo., automobile plant.

Some of the Many Uses of

Fire-Resisting Wallboard In Industrial Plants

For Protecting Mill or Frame Construction, for Altering Old Plants to Make Them More Attractive and Serviceable, for Constructing Kilns and Storerooms, and in Other Applications

By H. E. JEDDY
Engineer, Fireproofing Dept., United States Gypsum Co., Chicago, Ill.

PLANT alterations, change of production methods or the reduction of fire hazard often require extensive rearrangement of industrial buildings. Also, in many old plants there are unsightly walls or ceilings which it is sometimes difficult to make presentable. Frequently the production problem is such that clear, smooth walls are almost necessary.

One of the common and simple methods of making such alterations is by means of wallboard, as will be described here, together with other industrial applications of this material. For general industrial purposes, it is usually advisable to use one of the wallboards made of fire-resisting material.

This material is made of non-combustible gypsum, a rock product, to which is added some wood fiber for binding purposes. Wallboard comes in sheets, 3/8 in. thick and either 32 in. or 48 in. wide. Standard sheets may be obtained in lengths of 6, 7, 8, 9 or 10 ft. It is covered with a heavy fiber material; its edges are square and the fiber surfacing is folded back into the gypsum so as to prevent fraying and increase the strength of the edges. The board can, therefore, be nailed without danger of the edges being broken if ordinary care is used. It is not necessary to drill and bolt wallboard unless it is to be fastened to iron or steel shapes. This material may be nailed as easily as wood lumber and cement-coated nails are customarily employed.

Carpenters find that wallboard is much more easily worked than lumber and also more quickly applied, as it comes in large sheets which can be sawed to fit as easily as lumber. Also, the large area in each sheet makes it easy to cover considerable surface at a time. The wood fiber contained in the wallboard helps to make it sufficiently flexible so that the sheets may be adapted to slight curves where the nature of the construction requires it. Even though the sheets are quite large they are light enough so that they may be easily handled.

Some of the characteristics which make this material adaptable to industrial plants are that it presents a surface which may be easily finished, it may be applied to either walls or ceilings, and does not disintegrate so that particles may drop, such as may happen with plastering, and fall into the product or machines. This is of particular im-

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portance in food products, textile and other similar plants. Also, this gypsum board is non-combustible and has sufficient fire-resisting qualities so that an ordinary fire does not affect it. In addition the amount of heat transmitted through the board will not char or damage the wood backing, except in an extremely destructive conflagration. Other characteristics which make this material of considerable value to industrial men are, the ease with which it takes a finish, a surface which does not crumble and the fact that it is not affected by ordinary atmospheric conditions.

One of the many advantages of wallboard in industrial construction is that it provides a smooth,uniform surface which can be covered with any kind of paint, calcimine or similar protective or decorative covering. If wallboard is to be painted, a priming coat of half varnish and half paint is recommended. This gives a surface which will take any finish. These decorative possibilities are of considerable importance in industrial plants, and this characteristic of wallboard makes it available wherever a high degree of light diffusion is required or where a tight, non-crumbling wall or ceiling is desired. Hence, one of the most common uses is in finishing over old industrial plants. For example, in case it is desired to devote a portion of the plant to office purposes, the brick walls are generally covered over with plaster or some form of wallboard. Wallboard may be applied by the plant carpenter; so it is not necessary to lath up the surface and get outside plasterers to finish the job.

In applying wallboard to brick or masonry walls it is recommended that 2-in. by 2-in. furring strips be set on the standard 16-in. spacing; 1-in. by 2-in. furring may be used, but this does not give as substantial a support as the former. Wallboard is nailed directly to the furring strips. Headers are placed at the top and bottom so that all edges are supported. It is, of course, necessary that the furring be substantially attached to the wall and evenly lined up.

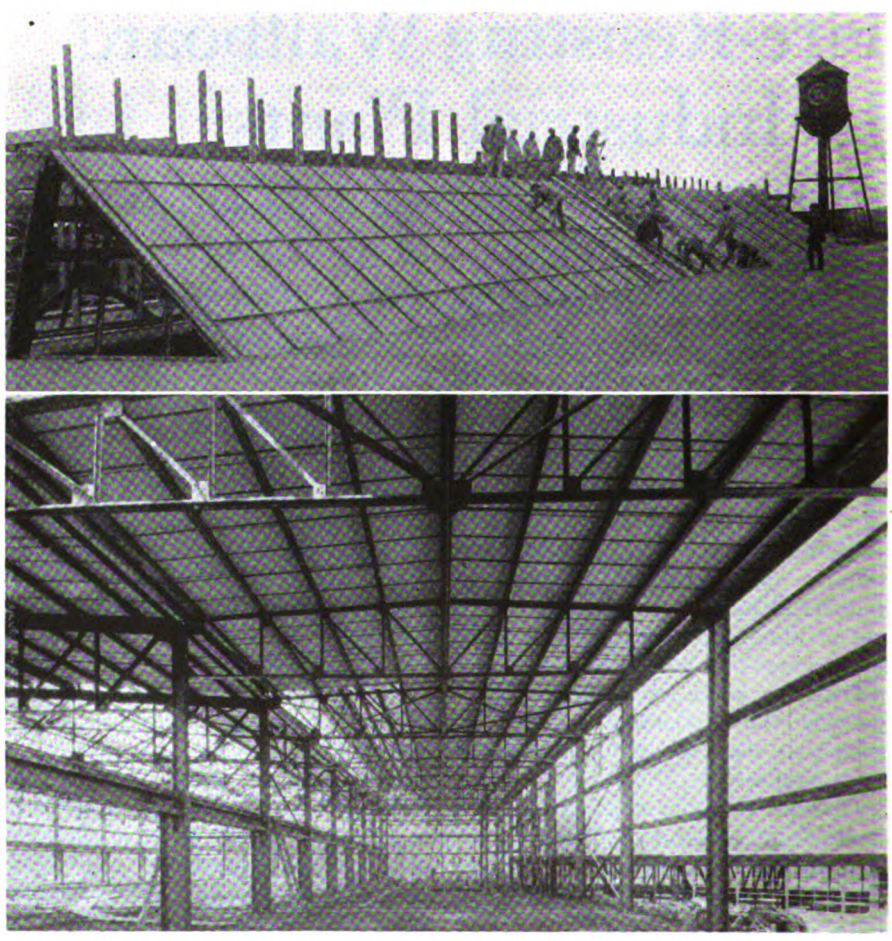
In covering up chimneys, columns or other projecting corners, it is not always necessary to fur against the wall. It is usually better to build a separate framework of 2-in. by 4-in. plank, which is not anchored to the chimney.

Frequently plants engaged in producing textile products, particularly if extensions require that they remodel old buildings, find the use of wallboard advantageous for lining the walls and ceilings. Some of the accompanying illustrations show how this was used at the Taubel-Scott Hosiery Mill, Lenoir City, Tenn. Here 55,000 sq. ft. of Sheetrock were used in the remodeling of an old brick factory. Inasmuch as in this case the joists were not sized it was necessary that the ceiling be cross-furred and the wallboard nailed to the furring. In doing this, all electric wires and sprinklers were lowered and the boards were installed without interruption to operations.

Where it is desired to make a joint between the boards, which is not noticeable, a special plaster, called "joint finisher," is applied to the crack. If care is exercised in finishing over these joints they will hardly show when painted. Sometimes panel molding is placed across these cracks to give a paneled effect. In this hosiery plant, however, the joints between the boards were left unfinished just as the edges of the sheets fitted together, since appearance was not a factor deserving of extreme consideration.

The wall surfaces were treated in the same way. The entire wall and ceiling were then covered with a mill white paint. This made a clean, well-lighted room with plenty of reflecting surface which was not only sanitary but did not sift dust, as would have been the danger with the former wall and ceiling surfaces. Such construction makes a room an attractive work place; there is a pronounced contrast between this and rough brick walls and unfinished ceilings. This is particularly advantageous in plants where women workers are generally employed.

In this same hosiery mill, Sheetrock was also used in the construction of the lower portions of the various bins in the storeroom, as shown in an accompanying illustration. This gives not only a clean



Exterior and interior views of a special fireproof roof construction at the Essington, Pa., plant of the Westinghouse Electric and Mfg. Co.

Here a gypsum wallboard is used as the bottom of the mold for casting the roof sections which are reinforced with steel fabric and a special Pyrofill mix of the desired thickness is poured into this mold. This material binds with the wallboard, and hardens into a monolithic construction which is covered with a water-proofing preparation. The wallboard forms a smooth and also fireproof ceiling.

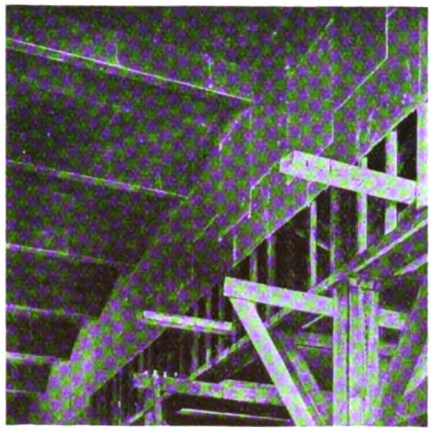
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and sanitary construction, but it is also practically fireproof. The ceiling and walls of this room were finished off with wallboard the same as in the rest of the factory.

Partitions extending part way or entirely to the ceiling may also be made in this same way from wallboard. As the industrial man has the choice of sheets from 6 to 10 ft. long, it is usually possible to get a length which is equal to the partition height without extra cutting, and so save considerable labor in its erection.

The foregoing applications by no means cover the entire list of uses of this material for industrial reconstruction. Garages, for example, are frequently lined with it, both for the heat insulating value and also on account of the practically fireproof construction which it gives. Other uses are in locker rooms, rest rooms, lunch roooms and practically any other place which it is desired to finish off or enclose. The construction is not only economical, but easily applied.

In addition to the use of this material for refinishing on the inside of industrial buildings, one of the earliest instances of the use of this material for the reconstruction and protection of industrial buildings was in the Boston & Albany R. R. freight warehouse and in the Cunard Line pier freight house at East Boston, Mass. In these, the fire hazard presented by the wood construction was a matter of much concern. After extensive fire tests the entire interior wood construction of these large and highly combustible buildings was protected with gypsum plaster board. This material was quite similar to the present gypsum wallboard, except that it was thicker and the panels were of different size.



Gypsum board is used here for beam protection as well as for sheathing on ceiling and partitions.

This was applied to the freight warehouse of the Boston & Albany R. R. to reduce the fire hazard in an open frame construction. Inspection after 23 yr. of service showed that, except in a few spots where water had leaked in through the roof, the material was as good as ever. However, the material is damaged by water only after long and repeated exposure to alternately wet and dry conditions.

All of the large wooden roof trusses in these warehouses were fire-protected by two layers of ¼-in. board with the joints broken in both directions. The rest of the construction was covered with ⅜-in. plaster board, sawed to fit and applied so as to follow the contour of the construction and avoid concealed air spaces. Wooden columns, girders, beams and ceilings were treated in the same way. Also, a number of non-bearing fire-resisting partitions, which consisted of wooden supports covered on both sides with the gypsum plaster board, were constructed to divide the buildings into fire sections.

When this installation was inspected recently, some 23 years after its erection, it was found to be in good condition except for a few places where excessive leakage through the roof had caused damage to some of the panels. However, no distintegration due to the humid atmosphere along the water front was observed. A similar construction has been used in a number of other warehouses since.

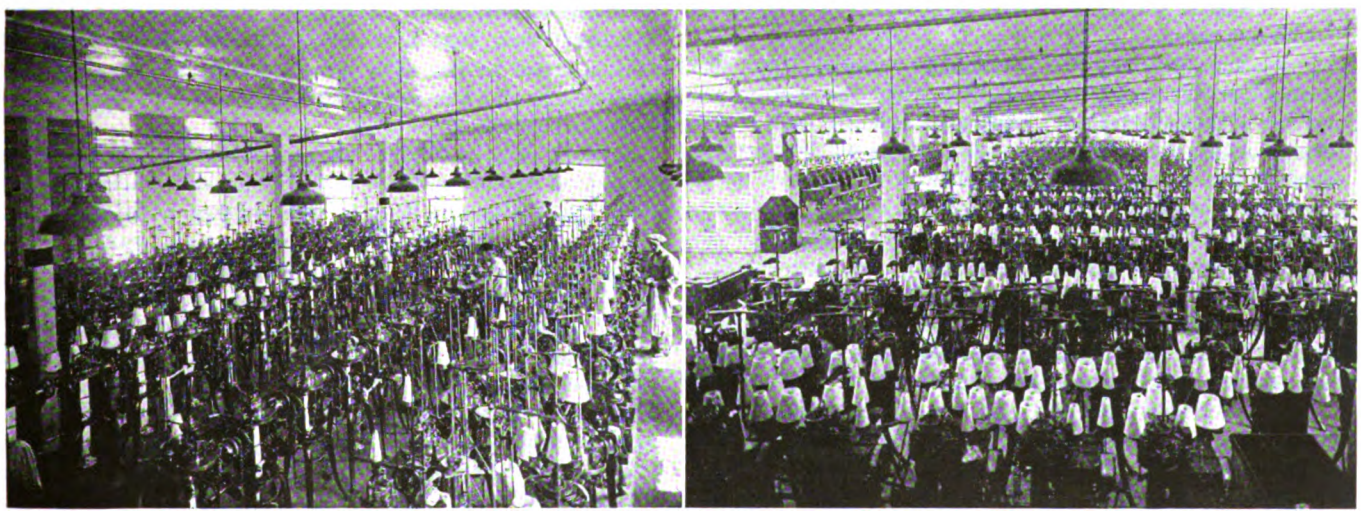
Because of its fireproofing qualities and ease of construction wallboard has been used for the construction of dry kilns in numerous industries. Here the primary requirements are incombustibility, heat insulation, ability to withstand humidity, accessibility, economy, and ease and rapidity of installation. Many of the large motor car manufacturing companies have used this material in the construction of their drying kilns for varnished work. Altogether from 8,000,000 to 10,000,000 sq. ft. have been used for this purpose.

Three such kilns, one of which is shown in an accompanying illustration, installed in 1919 in a truck factory in Buffalo, N. Y., may be considered as typical of the general construction used. These kilns cover a ground area 40 ft. by 60 ft. and are 8 ft. 6 in. high. In the construction of these, a frame of 2-in. by 4-in. lumber was erected with studding spaced 32 in. on centers, with a header every 48 in. Wallboard was

(Please turn to page 258)

Two views of a remodeled interior in a hosiery mill.

The walls in this plant were rough brick and the ceiling joists were not covered when the Taubel-Scott Hosiery Mill, Lenoir City, Tenn., decided to remodel the plant. Electric wires and sprinklers were lowered and the wallboard installed on the ceiling without interruption to operation. Both wall and ceiling surfaces were then painted with a mill white paint, which makes them much more attractive and sanitary, and also prevents dust or grit from sifting through the ceiling or breaking loose from the walls and so getting into the product or machines.



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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E. GOODING A. J. WHITCOMB

Chicago, May, 1925

The Wrong Way To Decrease Cost Of Maintenance

ONE of the first principles of good management, as well as effective cost accounting, is to charge all expenses to the individuals, products or departments which are responsible for them and would be most affected by an increase or decrease in these expenses. In this way those individuals responsible for the expenses have a more vital interest in keeping them within reasonable bounds. This is as true of the cost of maintenance as of any other industrial expenses. However, not all plant managers consider fully this important point.

Recently a practical man, who had been supervising the maintenance work in a large plant, pointed out a good example of the futility of expecting to get results when this principle of managerial control is ignored. In this plant all maintenance costs, for both material and labor, were charged simply against "Maintenance," probably to eliminate the bookkeeping cost of apportioning these expenses to the various departments. As a result the maintenance engineer was the only man interested in reducing this cost. The only way he could do this was to try to economize in time or material; in other words, he had to skimp on the repair jobs which, in turn, tended to increase the frequency of the repairs.

Since the foremen had no charge against their departments they were inclined to neglect the equipment and run it until it failed. They also resented any interference as long as the motors and drives would operate, even though a few minutes' attention would have made a worthwhile saving in the ultimate cost. The management, in turn, took the maintenance engineer to task for the heavy expenses charged to his department. Caught thus in the cross-fire of the foremen and of the management, the maintenance engineer finally gave up and a new man came in to fight the same battle, that several of his predecessors had lost.

Men who think that they can lump maintenance costs in a pile and expect to save by merely looking at and complaining about its size are only "kidding" themselves. The only way to keep maintenance costs down is to attack them at the source and make each department responsible for its own costs. Then, if the repair work is skimped the foremen have a perfect right to complain loudly; however, if the foremen neglect the equipment, the maintenance engineer has an opportunity to defend himself. Luckily, such conditions as described are in the rapidly-decreasing minority.

When Did You Test Your Transformer Oil?

BECAUSE it does not move and the only sign of activity is a pump, we are prone to think that a transformer can run just a little longer without attention. Too often this "just a little longer" stretches out into months and years, sometimes with no apparent bad effects; and then again a very disastrous failure occurs which wipes out all of the time and labor thought to have been saved by not doing the required maintenance at regular intervals.

A plant recently visited illustrates a case where the trouble was caught in time. The transformers supplying vital feeders in the plant had not had their oil tested for several years. Samples were drawn and sent to a testing laboratory in another city. The tests showed the oil to be low in dielectric strength, so the oil in each transformer was run through a purifier. A year later the oil was again tested and found to break down at 15,000 volts across a 100-mil spark gap, when it should have broken down at 22,000 volts across such a gap. This time the oil was filtered until successive tests made on the job, showed that the samples of oil taken from each transformer would pass the required test.

Atmospheric conditions, nature of load cycle, and many other conditions have a bearing on when the oil will break down in the transformer during normal operation. Be on the safe side by making regular tests of the oil in your plant, and purifying the oil promptly when tests indicate that it is required.

Don't Misuse Your Fuses

THOSE responsible for continuous operation of motors and other electrical equipment in industrial works, know by experience just how much it costs to have a fuse blow. The cost of a renewal link is insignificant. The expense of having someone take out the blown fuse and replace it with a good one is only a little more. The real expense is the delay to production and the possibility of spoiled material that is in process.

A fuse is a safety valve and when rightly used it is a good friend. When a fuse blows, it is ridiculous to think that something is the matter with the fuse. Either the fuse was too small or the load carried was more than should be carried by the apparatus that the fuse is put there to protect.

An investigation made by Charles R. Hepner, chief electrician of the Willard Storage Battery Company, revealed that their so-called fuse troubles were due to their own carelessness and he is perfectly frank in calling it carelessness. Mr. Hepner found that the trouble could be attributed to six causes, none of which was a fault of the fuse. On page 228 of this issue,

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Mr. Hepner gives some very interesting data on the results of his investigation, together with the remedies that he applied with remarkable success in the reduction of motor outages. On page 40 of the January issue, A. W. Oppman described a fuse color scheme that he has used to prevent improper use of fuses.

Application of the methods and facts presented in these two articles will cut your fuse renewal costs and, what is more important, will reduce your power service delays.

If You Do Your Work Well Enough You Won't Have to Do It

PROBABLY everyone has wondered at times why promotion or salary increases did not come faster. In any particular case there may be a number of reasons why substantial advancement is slow in coming, or does not come at all. One of the most common reasons, however, is lack of that pride of craftsmanship which is satisfied only with the very best job that can be done. With that pride usually goes a willingness to undertake any task within reason and do it to the best of one's ability. On this point one of our readers recently made the following interesting and significant statement:

I have been through the mechanical machine shop and electrical maintenance and have taken considerable pride in handling any job which came along, whether I had ever seen it before or not, and doing it successfully; but I suppose that is why I am not doing it now.

The mere retention of a place on the payroll is not necessarily an evidence of real success—the kind that leads to foremanships and higher positions. Very mediocre ability can and oftentimes does find a more or less permanent place in industry, as well as in other lines. Nevertheless, the men who hold positions of responsibility in the industrial world have, in the great majority of cases, attained these positions only after a long training period in which conscientious and unremitting efforts were made to perform every job in a thoroughly workmanlike manner.

Taking it by and large, when a man learns how to do his work expertly and efficiently, he does not have to do that kind of work very long—he will be given the job of showing others how to do it.

What Do You Do With Old Equipment?

DISPOSAL of old equipment is one of those things that are frequently left to take care of themselves. Often the equipment is considered too good to be junked and there is a vague idea that it may some day come in handy as a spare, and is, therefore, worth keeping. Usually the result is that the equipment is shoved off in some out-of-the-way place. By the time that a use for it has arisen, it has been forgotten.

A case in point came up recently in a small plant that generates its own power. The direct-current generator in use was badly overloaded, by reason of additions to the plant. One day the inevitable happened—the commutator became so hot that the solder melted and the machine was put out of commission.

The service man who was called in to make the repairs recommended that a larger generator be purchased. The management would not consent to this and asked that some other solution be worked out—a case of making bricks without either straw or clay.

While passing through the boiler room the service man noticed an old alternator with a belted exciter, the whole outfit so covered with coal and dirt that it was hardly recognizable. He was told that it had been taken out of service five or six years previously, and forgotten. After some of the dirt had been scraped off he found that the rating of the exciter was large enough to enable it to carry the excess load on the main generator.

Several hours of hard work were required to put the exciter in running condition. After that it was a simple matter to belt it to the engine which drove the main generator. The problem was thus solved at trifling expense.

This incident has, with some variations, been duplicated in many plants, although the ending is sometimes different; a new piece of equipment has been purchased and the discovery later made that a discarded but still serviceable piece of equipment was available.

When equipment is taken out of service there are just two things to do with it: If it is worth keeping in reserve, put it in good condition and store it where it will be clean and not likely to be damaged. Further, a complete record should be taken and filed for reference. If the equipment is of such type or rating that it is not likely to be used again—sell or junk it. The sale or junk value may not be high, but it is far better to have this value in the form of money than in the form of useless equipment which serves merely to make an untidy-looking plant.

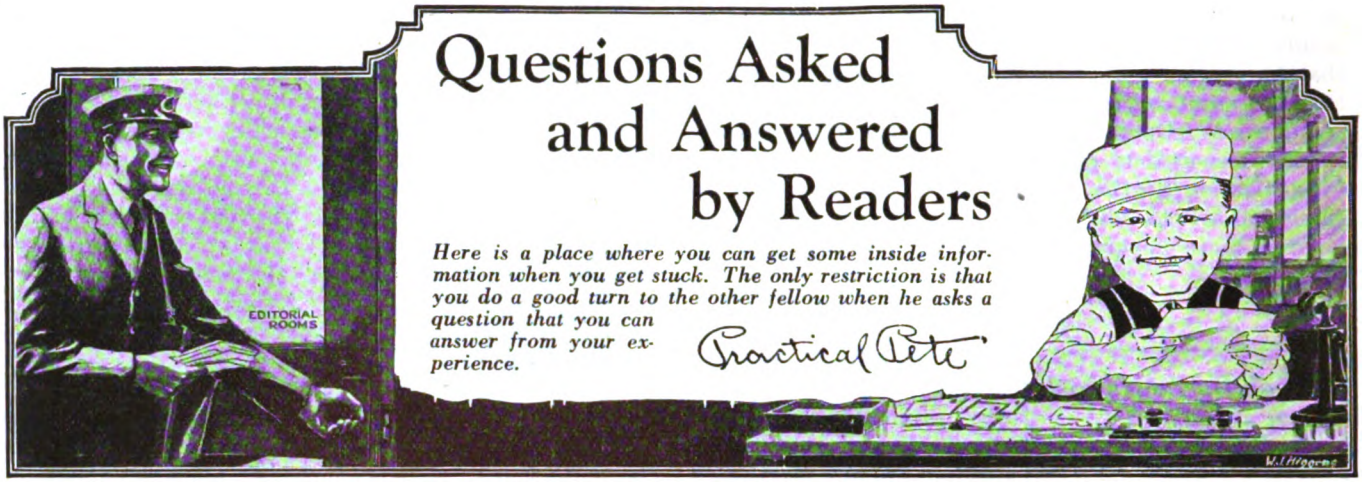
Poor Housekeeping Causes Most Plant Fires

FIRE losses during 1924 were exceptionally heavy since, even though there were no unusually large conflagrations, the total number of fires, according to the *Industrial Fire Chief*, probably exceeded that of any other year. Of these fires an estimate obtained from a careful study of fire records and confirmed by fire insurance executives, shows that probably 65 per cent were due to easily preventable causes. Inspection reports, by the same authorities, indicate that industrial as well as commercial concerns have skimped on expenditures for upkeep and repairs.

The natural effect of such neglect is a psychological reaction of the workers; a reaction of carelessness which is in keeping with the carelessness and neglect of the plant and premises. All of this tends toward careless housekeeping: one of the most common underlying causes of fires. Where fires are not directly traceable to poor housekeeping it is usually easy to show how they originated from carelessness imbued in men through prolonged association with slovenly surroundings.

Whether a plant is over-busy or just keeping going is no reason for neglecting maintenance and upkeep, nor plant housekeeping. If the plant is busy it has need for everything to be well done; if the plant is barely operating the wide-awake manager will find opportunity to squeeze in the necessary time to do this work at practically no additional outlay.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Comparative Advantages of Compensators and Primary-Resistance Starters—I shall appreciate it if some of our readers will give me their experience or opinions on the comparative advantages and disadvantages of compensators and primary-resistance starters for starting induction motors.
Cleveland, Ohio. F. G. H.

* * * *

Rewinding 110-Volt Generator for 6 Volts—I have a 110-volt, 0.25-kw., 2,000-r.p.m., shunt-wound generator and should like to know if it can be reconnected or rewound to give six or eight volts, for charging storage batteries. If so, will some reader please give me some information on the size of wire to use, number of turns and so on?
Allentown, Pa. A. H. S.

* * * *

Special Skid for Moving Machinery—We are planning an extensive rearrangement of machines such as lathes, screw machines and the like in one of our departments. I wonder if any of our readers have had experience in making a special skid or platform for holding such machine tools during the moving operation. I think that some such scheme as this would be quicker than trying to build a skid for each machine that is moved, but am hazy as to the best way of handling this kind of a job.
Milwaukee, Wis. G. F. H.

* * * *

How Does This Motor Start?—I have a motor made by the General Electric Company that has the following nameplate data: Ser. No. 79,281, type IS, class 4, form A, 60 cycles, 1,800 r.p.m., ½ hp., 110 volts. The nameplate does not say whether the motor is single phase, but as there are only two leads coming out of the machine, I think that it must be a single-phase motor. It has a solid rotor, no starting switch, and no split winding for starting the motor. The winding in the stator is similar to a chain winding. The armature has 36 slots, two of which are empty. The empty slots are spaced seven slots apart. Can some reader tell me how this motor is started from a single-phase power supply?
Oakland, Cal. N. N.

* * * *

Operating Motors in Parallel on Bridge Motion of Crane—Two series motors are used to drive the bridge motion of one of our cranes. Each motor drives one set of track wheels, so that the two motors are practically operating in parallel. They are controlled by two contactor panels operated from one master switch. With this combination the armature burnouts were so frequent that it was decided to connect the armatures of the two motors in series and the fields in parallel. As we still had burnouts it was decided to connect the armatures and fields all in series. This has eliminated a great deal of the trouble, but it reduces the speed of the bridge.

I would like to know what is the cause of the trouble that I have been experiencing. Can some reader suggest a method of connection that will eliminate the trouble from burnouts and at the same time give normal speed on the motors?
Indiana Harbor, Ind. A. R. D.

* * * *

Trolley Wire Supports for Monorail Crane—I have a monorail crane running on an I-beam, which has to travel around two rather sharp bends, and wish that someone would give me his experience as to the best way of installing and supporting the two trolley wires that feed this crane. How should I support the wires where they go around the bends?
Barre, Vt. C. G.

* * * *

Does Change in Transformer Connections Affect Rated Capacity?—I have three 100-kva., single-phase, 2,200-110-volt transformers, which I intend to connect in a bank to deliver three-phase power at 110 volts. If a delta-delta connection is used to connect the bank, what power capacity can I get from the transformers? Will I get the same power capacity from a star-star connection? I shall appreciate any information that readers can give me on this question.
Telluride, Colo. T. H. C.

* * * *

How Much Time Is Required to Wind These Stators?—I would like to know how much time should be required to wind semi-closed slot stators for 40-deg. and 50-deg., General Electric motors and also for the type CS motors made by the Westinghouse Electric & Mfg. Company. By this I mean the time required for insulating the cells, inserting the coils, putting in the wedges, and connecting. Will some reader give me what he thinks is a reasonable time for winding stators of the kind mentioned, having 36, 48, and 72 coils, and having horsepower ratings from one to ten?
Springfield, Mass. H. P. B.

* * * *

Why Does This Motor Run Slow?—We have two wound-rotor motors, each rated at 325 hp., 2,300 volts, 60 cycles, and 1,185 r.p.m. at full load. Both of these motors are running about 30 r.p.m. below their rated speed. The frequency of the power supply is normal, for the generators are running at their correct speed of 3,600 r.p.m. About nine years ago the ventilating fan blades were removed from the rotors of the motors and consequently during the summer the windings become quite hot. When the motors are running the pointer of the power factor meter swings continuously. The pumps that are driven by these motors have recently been overhauled, but there was no increase in the speed of the motor. Since the pumps are running at less than rated speed, the motors do not draw rated full-load current. Can some reader tell me what causes these motors to run at less than rated speed and how I should go about correcting the trouble?
Medicine Hat, Alta., Can. E. A. S.

Answers Received To Questions Asked

Supporting Lineshafting on Concrete Pillars—I have to support several long runs of lineshafting on concrete pillars and should like to know (1) if this is considered good practice. (2) Will it be necessary to use adjustable pillow blocks, or will the solid type be satisfactory? (3) Is there enough danger of the pillars settling or getting out of line to make it necessary to brace these in any way?
Brooklyn, N. Y. C. R. P.

Answering C. R. P. in the February issue, the ordinary place for supporting shafting in mill buildings is from the ceiling, but there is nothing wrong in supporting it on columns provided the columns themselves have been properly designed for this duty. Columns supporting lineshafting would have to carry not only the dead load from the floors above but also be able to stand the continued vibration of the rotating shaft and the cross-bending resulting from the pull of the belting. Without a knowledge of the detailed design of the columns, horsepower to be transmitted, spacing of the columns, dead load on each column and number, location, direction and size of the various belts, it would be impossible to give to this question an answer which would be correct in any particular case.

Assuming that this is a reinforced concrete building properly designed for factory or mill use and that the columns have been designed for the purpose stated, there would be no question about the propriety of mounting the shafting on the columns. With the same assumption, there would be no necessity of bracing the columns to prevent settling or movement out of line.

As to the necessity of using adjustable pillow blocks, this again is a matter which hinges on the design of the columns, their spacing, horsepower to be transmitted, lineshaft speed, and so on. If the shaft turns at a fairly low speed, and making the same assumptions as to proper design as above, a bearing similar to the Dodge rigid post bearing would ordinarily be considered satisfactory. With these, ample vertical adjustment is secured by means of elongated slots in the backplate or face. Horizontal adjustment can be obtained by the use of shims between the backplate and the face of the column. For higher speeds I believe that adjustable

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pillow blocks should always be used.

This raises the question of anchoring the bearings to the column. Modern reinforced concrete construction for mills and factories often makes use of commercial fixtures such as are manufactured by the Midwest Steel and Supply Company for supporting shafting, piping and the like. Shapes have been developed which can be placed in the forms and concrete poured around them. Other shapes have also been developed for use in buildings already constructed. When the building is already constructed and no special provision has been made to support shafting, piping and so on from the walls or ceiling it will, in most cases, be necessary to drill holes in the concrete and set in some one of the many kinds of expansion anchors to support the machinery. In some columns this may be very difficult to do because of the reinforcing iron embedded in the concrete. In drilling for such anchors the reinforcing iron must not be cut, for its usefulness would thereby be lessened if not entirely destroyed. In the case of small- or medium-sized columns, wrought-iron straps may be placed entirely around the column and the bearings fastened thereto by bolts, thus avoiding the necessity of drilling the concrete and setting anchor bolts. This method could be used with larger columns also, but the chances of being able to place the anchors properly without striking the reinforcing iron are better than in the smaller columns; also the cost of material and labor for the straps would be proportionally greater than for the smaller columns.

Fort Worden, Wash. E. I. PEASE.

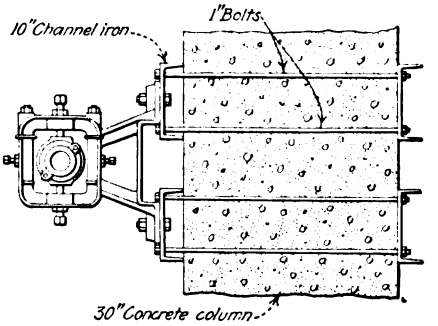
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Referring to C. R. P.'s inquiry in the February issue, it is common practice to support long runs of lineshafting on concrete pillars and this should give excellent results if the weight of the shaft and belt pull are not out of proportion to the size of the pillars. Most heavy lineshafts are supported in wedge-base, self-aligning pillow blocks on concrete piers installed especially for this purpose, but judging from the remark about bracing them, I judge C. R. P.'s pillars are building members, in which case they will probably be stiffer than any bracing that could conveniently be applied.

For supporting moderate-sized shafting—up to 3 7/16-in. or thereabouts—on rectangular concrete posts, we have found the arrangement shown in the illustration to be cheap, convenient to erect and very satisfactory in operation. The size of the channel iron must be proportioned to the size of the shafts and the width of the column, but for 3 7/16-in. shafts and a column width of 30-in., a 10-in. channel iron is about right. The channels are cut about 6 in. longer than the width of the post and drilled so as to bring the bolts close against the sides of the posts. Under the above conditions, use 1-in. bolts. Filling the space between the channels and the post with a heavy grout thoroughly packed in is important as it not only increases the bearing area and prevents the edges of the channel cutting into the post but materially stiffens the web where the hangers are bolted.

Adjustable bearings are essential, as it would be practically a hopeless and endless job to line up a long shaft by shimming out solid boxes and jacking them into line.

Settling or leaning of posts, buildings or any other form of structure is altogether a question of foundation, which must be of sufficient area not to exceed 2 tons pressure per sq. ft. on any part of the area, and less on loose, sandy soil when the structure is subject to vibration. The foundation must be carried down below the frost line and preferably should go down to solid soil.



Bracket hangers may be conveniently supported on channel irons bolted to concrete columns.

If this is impossible the solidest spot available must be chosen and the base area increased correspondingly. Settling is bound to occur if an attempt is made to build on recently filled-in soil. In such cases, driving piles to a firm bottom is the only way of getting a satisfactory job.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

* * * *

In answer to C. R. P. in the February issue, it would be well to use an adjustable pillow block, if for nothing more than to take up wear on the shaft or in the bearings, as a multiplicity of sags will increase drive friction.

If there is any danger of the pillars settling, by all means use a pillow block which can be adjusted. However, as the pillars are concrete, there is not much chance of them settling.

Jamestown, N. Y. H. S. RICH.

* * * *

In reply to C. R. P. in the February issue, (1) I do not consider it good practice to support lineshafting on concrete pillars except when anchor bolts are provided for this purpose during the construction of the pillars.

Good results may, however, be obtained in some cases by drilling holes in pillars with a star drill for lag screws. Each hole should be made 3/8 in. larger at the entrance than the diameter of the lag screw to be used and gradually tapered out larger so that the bottom of the hole is 3/4 in. larger than the screw. Then run the holes full of molten lead and drill them out the size of the lag screw, less the depth of the thread.

I think it is good practice to put a small quantity of oil or grease of some kind in each hole before pouring in the molten lead, as this will eliminate danger of explosion in case there is any dampness in the holes. In all horizontal holes cut a groove in the top side deep enough to afford a vent so that the hole will fill full at the bottom.

(2) It is advisable to use an adjustable bracket, sometimes called a post hanger. Pillow blocks may be used but undoubtedly they could only be properly lubricated by the use of grease cups.

(3) Settling of the pillars will depend largely upon their foundation and the weight that is applied upon the floors above, which they support.

Marietta, Ohio. E. L. WAY.

* * * *

Referring to C. R. P.'s question in the February issue, (1) local conditions and special requirements to be met govern to a great extent certain practices. Without definite information and specifications it is rather difficult to comment intelligently on this question. However, generally considering the problem, it can be done to agree with good practice.

(2) Adjustable pillow blocks have the advantage of comparatively easy adjustment for alignment by virtue of their design, although they are not absolutely necessary. The solid type can be used if mounted on shims for adjustment in one direction, and by using slotted or elongated mounting holes adjustment can be obtained in the other direction.

(3) The question of concrete pillars to support the shaft bearings involves a survey of the sub-soil conditions. Good, solid, dry earth or hardpan should form the basis on which to build the concrete pillars to assure no settling due to change in the sub-soil. For the foundations and pillars a concrete of 1-2-3 mix should be used. Use as little water as possible to obtain the final maximum strength from the concrete. If the torque on the shaft is at such an angle as to put a bending moment on the concrete pillar, use several reinforcing rods through the whole length.

Concrete that is well tamped and not too wet, settles only slightly during the period of its initial set which is about 45 min., depending upon climatic conditions. After the first set to the final set, which requires about six days, practically no shrinkage occurs. With the proper care in preparing the foundations, placing the forms, and mixing the concrete, no difficulty will be experienced in settling or shrinkage of the concrete pillars.

Milwaukee, Wis. E. H. LAABS.
Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,

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In the February issue, C. R. P. asks Practical Pete whether concrete pillars are good supports for lineshafting. He can rest assured that concrete is an eminently satisfactory material for this purpose. Where it has apparently proved otherwise, the trouble was not due to any inherent defect of concrete, but to the method of installation.

A frequent and unreasonable demand made on concrete is that it carry heavy and vibrating loads the day after it is

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poured. While the high-alumina cement now to be had will give a concrete that attains a large part of its ultimate strength in a day or two, concrete made from the common cement must be permitted to set for a considerable time in order that it may become sufficiently strong.

There has been much discussion as to whether bearings or machinery should be set directly on the concrete base or on an interposed timber. Both methods of installation have proved satisfactory. The advantage of setting the equipment directly on the concrete is that the latter then becomes in effect an integral part of the machine and as such assists in absorbing vibration. Capping the concrete with timber enables one to readily fasten equipment with lag-screws when the hold-down bolts do not happen to be in the desired positions, but aside from this feature, the wood offers no real benefit and, as I shall show, may be a positive detriment.

Some years ago, among the power plant equipment in my charge was a toothed-roll crusher used to break mine-run coal to stoker size. This had a very light frame for the size of the rolls and the work required of it, and gave much trouble by moving about on the timber frame interposed between it and the concrete foundation. It had been necessary to place guides against the drive belt to keep it on the pulley, and the crusher running. Tightening the nuts on the foundation bolts availed little because the timber was oil-soaked; bolts passing through timber are not well adapted to taking bending and shearing stresses. We took out the timber, cut the threads on the foundation bolts down to the concrete, replaced the crusher, and its quiet running thereafter made us feel a bit ashamed.

On another occasion two bearings out of eight that carried a quill-shaft driving a number of grinding mills, gave trouble from apparent settling of the concrete piers. All of the bearings rested on 8-in. by 12-in. oak caps, the 8-in. dimension being vertical. While the bearings were provided with base plates that permitted lateral adjustment, they could not be adjusted vertically; so shims were used to line up the offending bearings. An examination showed that six of the oak caps were of the same thickness while the other two (those under the offending bearings) were ¼ in. less in thickness. The conclusion was that the six caps had been cut from dry timber while the other two had been cut from green or wet timber, and had shrunk in drying and disturbed the alignment of the shaft. This conclusion was strengthened by marks on the under side of these caps indicating that they had been chipped to the required thickness with an adz at the time of installation. The inference is obvious—when cutting timber for use in supporting machinery, be sure that it is dry.

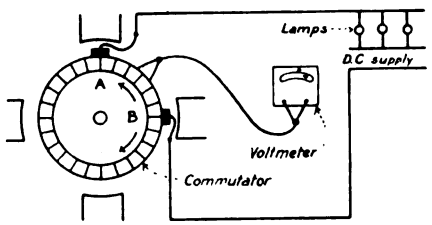
C. R. P.'s question does not indicate what his concrete "pillars" are. Pillars may be anything from piers to columns. His intention to use pillow blocks indicates that his shafts will rest on the tops of supports of some kind. If this is the case he will be compelled to use a concrete (or possibly brick) base anyway; so he may as well carry the concrete up to the pillow blocks, and any shimming that may have to be done in the future can as readily be done on concrete as on wood. Whether the pillars will require bracing depends on their height.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

Testing D.C. Armatures With Voltmeter—(1) Will some reader please tell me where to place the lampbank leads on the commutator when testing direct-current armatures with a voltmeter? For example, in the case of a four-pole armature should I touch the leads to the commutator on the quarter or on the half? Where should the leads be placed on a six-pole armature; or an eight-pole armature? (2) When testing a four-pole armature I touched the lampbank leads to the commutator on the quarter and got a good reading on the meter until I came to the next quarter of the commutator. Then the deflection was in the opposite direction. When I reversed the meter leads there was no reading on two bars of the quarter. Continuing ahead I got a good reading until the next quarter was reached. What did that indicate?
New York, N. Y. H. B.

Referring to H. B.'s question in the January issue, (1) for a four-pole, six-pole or eight-pole field the test current should be applied at two adjacent brush contact points as indicated in the diagram, and the bar-to-bar test made between the two contact points only. When this section has been tested, either revolve the armature or shift the two contact points, keeping the same spacing and again test between bars. This method is a desirable one since it approximates closely the actual current flow in the armature. In the diagram the flow of current is shown by arrows.



Application of voltmeter test to direct-current armature.

(2) Referring to the diagram, assume that the tester begins at *A* and tests towards *B;* it may be assumed that, as indicated, the flow of current through the winding is from *B* to *A*, as *B* is connected to the positive supply lead. Should the test be carried beyond *B* without changing point *B*, the current in the next portion of the winding will be flowing in the opposite direction and the voltmeter will show a reversed reading. If two positive and two negative contacts were made at one time at the quarter points, a continuous test could be made, reversing the meter leads after passing each brush or contact point.

A zero reading between two bars will generally indicate a short-circuited coil. The contacts should cover about the same area as a brush so as to approximate the normal current flow conditions as closely as possible.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

In answer to the question by H. B. in the January issue of INDUSTRIAL ENGINEER, the following methods should be used: For a two-pole armature the lampbank is placed on the 180-deg. points. For a four-pole armature the lampbank is placed on the 90-deg. points. For a six-pole armature the lampbank is placed on the 60-deg. points. For an eight-pole armature the lampbank is placed on the 45-deg. points.

The rule is to place the lampbank leads on the points corresponding to the spacing of the brushes on any multi-polar machine.

As the meter leads are touched to adjacent commutator bars around the armature the readings should be the same, or very nearly so, for a perfect armature. A double voltage reading indicates a defective winding between the two adjacent bars. This may be a short-circuit between two coils, or a double ground. A reversed reading on any one section indicates a reverse connection to the commutator. No reading between two adjacent bars would indicate an open circuit to one or both of these bars. In that case by bridging these two bars, or one of them, and making contact with the bars on each side a higher reading than normal will result.

In passing from one section, such as a quarter-section on a four-pole armature, to another, the reversal of the meter leads is necessary due to the winding of the armature. However the readings should all be of the same value across any two adjacent commutator bars.

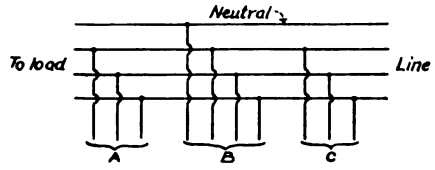
H. B.'s second question would indicate that an open circuit existed on the two bars that showed no reading. Under service this armature would show a heavy spark lapping over these bars when they came under the brushes.

One of the worst troubles to encounter is a "flying ground" wherein a connection of the coil becomes grounded only when the motor is up to speed, due to centrifugal action. In this case the method of testing is to mount the armature in a cradle and rotate it by another motor at the normal speed. A test set can then be used with one lead on the commutator and the other on the shaft of the armature. When the speed is correct the ground will show and it can usually be located by allowing a heavy current to pass through the test leads on the revolving armature. The commutator bar connected to the defective soil will show a pit where the circuit is broken under the lead on the commutator. Care should be taken to have the lead pressing upon the commutator at a point other than where the brushes will ride. Also care should be exercised to see that the current is not heavy enough to cause a heavy pit in the commutator.

Armatures can be tested in the frame, thus eliminating disassembly, by using two adjacent brushes reversed and lifting the others from contact with the commutator. The low-voltage leads are then connected to the armature leads on the motor terminal block. The armature should be wedged to prevent rotation when this procedure is followed. NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

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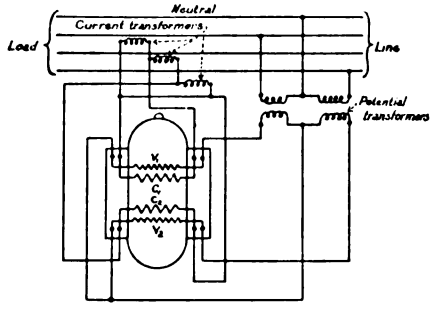
Connecting Westinghouse Type C Watt-hour Meter to 3-Phase, 4-Wire Circuit—Will some reader please tell me how to connect a Westinghouse, type C, switchboard, induction watt-hour meter to a three-phase, four-wire system having 2,300 volts between the neutral and each phase wire and 4,000 volts between phases? In the diagram, *A* and *C* are three-wire circuits supplying current at 4,000 volts, three phase, while *B* is a three-phase, four-wire circuit. One meter must measure the total power consumed.



The current transformers must be delta connected and three 2,300-volt voltage transformers must be used, as there are no 4,000-volt transformers on hand. I should also like to know whether it makes any difference if two or three current transformers are used on feeders *A* and *C*.

Guayama, Porto Rico. R. S.

Answering the question by R. S. in a recent issue, I assume that it is desired to measure the total energy of circuits *A*, *B* and *C* by a single meter.



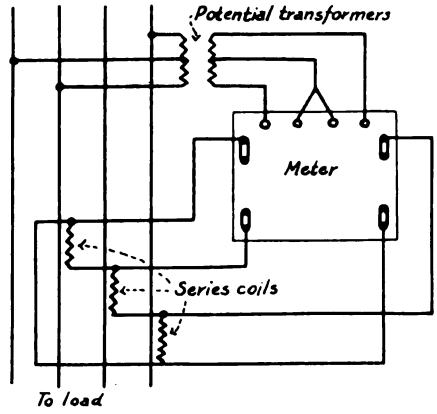
Internal and external connections of type C watt-hour meter connected to three-phase, four-wire circuit.

The diagram shows the conventional method of connecting this type of meter; the secondary current transformer connections only are shown. In the diagram V_1 and V_2 represent the voltage coils and C_1 and C_2 the current coils. I have attempted to show the connections at the terminal board as closely as possible in their actual physical arrangement. As previously stated, a meter so connected in the supply to circuits *A*, *B*, and *C* will register the total energy consumption of the three. On circuits *A* and *C*, if it is desired to measure the energy separately, two current transformers will be sufficient to secure proper registration.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

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In reply to R. S.'s question in a recent issue, the diagram shows a standard hook-up using delta-connected current transformers. This diagram shows the connection used for a four-wire, three-phase meter, which must be used, as a three-wire meter will not give accurate readings. A four-wire meter differs from a three-wire meter, mainly in the current coils. The four-wire meter has four series coils, two of which are connected in series and



Method of connecting type C Westinghouse watt-hour meter to four-wire, three-phase circuit.

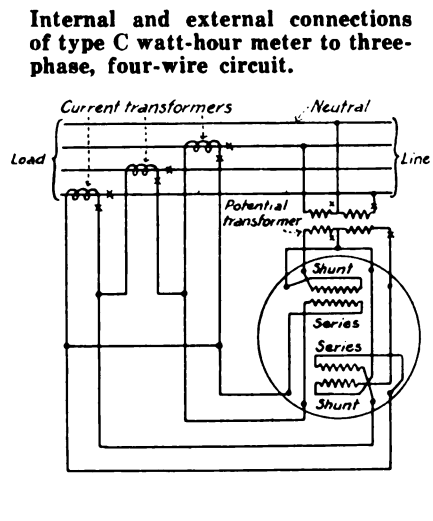
carry the current in one line wire. One coil in each element must be taken for the foregoing connection. The other two series coils, one for each element, are separate and each carries the current in one of the other line wires. The total energy will be registered when the meter is connected in this manner in a four-wire circuit, no matter how much out of balance the load may be.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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With reference to the question by R. S. in a late issue, the windings in a meter consist of a set of current coils and a set of potential or voltage coils. The current coils must be connected in series with the current to be metered and the potential coils connected in shunt with the circuit on the *line* side of the meter. In the diagram it will be noted that the common point of the primary of the two potential transformers is connected to the neutral wire of the circuit, and the remaining two primary wires are connected to any two of the remaining three wires of the circuit. This makes it possible to use two 2,300-volt transformers for the potential circuit of the meter. As regards using two or three current transformers in branch circuits *A* and *C*, two current transformers in each circuit will be sufficient, but as the total energy is recorded on the three-phase,

Internal and external connections of type C watt-hour meter to three-phase, four-wire circuit.



four-wire meter, it will not be necessary to meter these circuits unless the consumption of these circuits is to be checked against the total meter reading.

Goldfield, Nev. PHIL D. COMER.

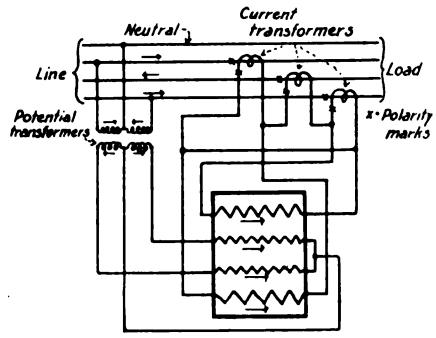
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In answer to R. S.'s question in a recent issue, the sketch shows the correct connections for a type C Westinghouse switchboard watt-hour meter. In this connection three current transformers are used, one in each phase, and two potential transformers of 2,300-volt primary rating are connected to two phases and the neutral; that is one side is connected to the phase wire and the other to the neutral.

The potential transformers that he mentions can be used and are the correct ratio, 20 to 1, for this installation. One phase is dropped in this four-wire connection due to the fact that all we need is potential of equal voltage on three wires; so with a pressure of 2,300 volts on the primary we will have 110 volts on our secondaries, the same as if this were only a three-wire circuit.

Galva, Ill. C. W. ROSELLE.

Method of connecting Westinghouse type C watt-hour meter to three-phase, four-wire circuit.



Method of Driving One Generator with Two Engines—Can some reader suggest a practical and efficient method of driving a 50-kw alternator by two oil engines of 37½ hp. and 50 hp., respectively, so that either or both engines may be used singly or together? If it is possible to devise such a drive with these engines operating singly or together I would have a selection of three horsepower capacities, 37½, 50, 87½, with which to meet the power demands. The peak load is about 45 kw., but the load is often much less than this. With such an arrangement it would not be necessary for me to buy a second alternator and install synchronizing equipment.

I shall be very grateful for any advice or suggestions you can give me.

Youngstown, Alta., Can. W. C. A.

In answer to W. C. A.'s question in a recent issue, I would like to tell him of an installation that was used for a number of years in a rolling mill in the Birmingham district. The mill was driven by an engine and a motor; they were placed in line one behind the other. The engine was behind the motor and had a larger pulley; so it was easy to place the motor drive pulley between the two sides of the belt on the engine. As the speeds of the engine and motor were different, the pulleys were also of different diameters. The motor belt was next to the pulley and the engine belt ran on top of the motor belt. This drive gave

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satisfaction and was a good way to utilize the two prime movers.

To adopt this method of drive to your problem, I would suggest that you put a clutch on both engines and drive the generator in the same manner as outlined above. Or the generator shaft could be extended and an engine fastened to each end. If this method of drive were used, there would have to be some kind of clutch or magnetic coupling between the engine and generator to allow either engine to be used independently of the other. I believe, however, that a belt drive would be the most satisfactory, as the two engines probably run at different speeds and this condition could easily be taken care of with a belt drive.

GRADY H. EMERSON.

Birmingham, Ala.

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Lay Out of Typical Three-phase Installation—Will some reader give me (1) a diagram of a typical, three-phase power installation from the power company's wires to switchboard, including transformers? (2) What transformer connection is used most, and why? Windsor, Ont., Can. J. A. L.

In reply to J. A. L.'s inquiry in the February issue, much will depend upon the voltage, location and amount of power to be purchased. A large consumer, who is served directly from a high-voltage transmission line, will usually have a small outdoor substation with high-tension disconnect switches, lightning arresters, step-down transformers, sometimes with a high-voltage oil switch on the primary side, and an oil switch on the secondary side. Inside of the substation there will be the meter transformers and the connections to the consumer's bus. The location of meter transformers depends upon the form of contract with the power company, but these usually provide for current to be furnished at the secondary voltage, in which case the meters are located as described.

For small consumers in cities, distribution is usually at 2,300 volts, in which case the hook-up is usually from the power company's line through high-tension fuses to primaries of transformers, from secondary of transformers to consumer's oil switch, which should be provided with overload relay but need not have no-voltage protection —this being on the individual motor lines—then through the meter transformers to the consumer's bus.

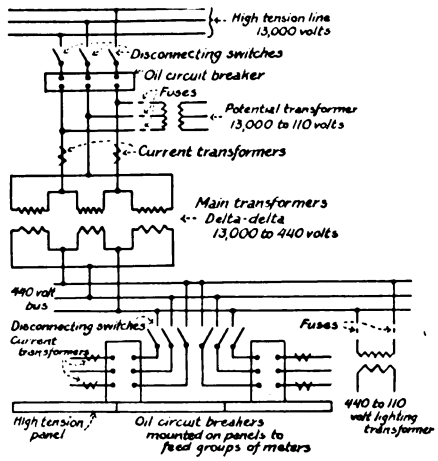
It is preferable to have the step-down transformers three single-phase transformers connected in delta, since if anything happens to one of them, the remaining two can be connected in open delta and about 58 per cent of the capacity of the original three obtained while the third is being repaired.

J. A. L. should consult the local authorities as all power companies and most localities have individual requirements which must be satisfied before the installation will be approved for service.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

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In answer to J. A. L.'s question in the February issue, (1) if the high tension lines are not over 22,000 volts, the disconnecting switches, high-tension



Layout of typical three-phase power installation receiving energy at 13,000 volts.

circuit breaker and transformers may be placed inside of the building, the breaker being mounted on a pipe framework and controlled by pipes and bell cranks from a panel in the same switchboard as the low-tension breaker. If the voltage is over 22,000 volts, all high-tension apparatus should be installed out of doors and the circuit breaker electrically operated. Low-tension breakers may be mounted directly on the panels, or on a pipe framework. The high-tension panels should have a wattmeter, voltmeter and ammeter with switch so that it will indicate current in all phases. Each low-tension panel should have an ammeter with switch and one panel should have a voltmeter connected through fuses to the low-tension bus. The diagram shows a typical three-phase layout.

(2) The most common transformer connection is the delta-delta. If trouble should develop in one transformer it may be cut out and the remaining transformers operated open-delta. Under these conditions, the two transformers will have about 58 per cent of the original capacity. Another common transformer connection is the star-delta with grounded neutral. The advantage of this connection is that the voltage stress to ground on the transformer insulation is only 58 per cent of the line voltage. If the high-tension side is delta-connected, the insulation is subjected to the full line voltage. The disadvantage of the star connection is that in case of trouble with one transformer it must be repaired or replaced before service can be resumed.

Boulder, Colo. RALPH MCKINNEY.

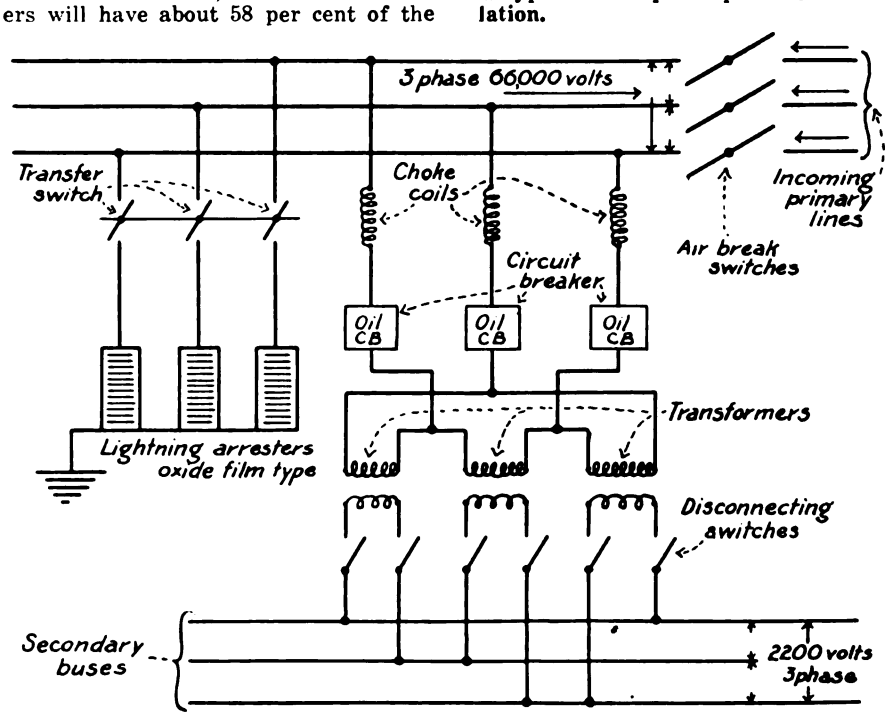
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In answer to J. A. L. in the February issue, I hope that the accompanying diagram of a three-phase installation will answer his first question.

The delta connection is the most frequently used transformer connection for ordinary industrial installations, as it is more convenient in case a damaged transformer has to be taken out of service. All that is necessary is to disconnect and remove the damaged transformer; then the two remaining transformers can be operated in open-delta. The capacity of the bank of transformers will be reduced to 58 per cent of its original capacity, but to that extent service can be maintained. In other words, one of the big advantages of this connection is that three-phase power is still available with two transformers, without any change in connections. As a general proposition, the delta connection ranks first in convenience of operation, second in low potential stress on the windings and fourth in low first cost. Many power companies use both star and delta connections, or a combination of both in order to be able to make changes in line voltage conveniently to meet new conditions.

Chief Electrician. LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

This diagram gives the layout of a typical three-phase power installation.



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Voltage Rating of Fuses for 440-Volt Circuits—Will some reader please advise me as to the proper kind of fuses and fuse cutouts to use on 440-volt, three-phase, 60-cycle circuits? Should I use 600-volt or 250-volt fuses and cutouts? (2) Is it practicable to use fuses above 300-amp. rating as entrance fuses, or would it be better to use a circuit breaker?

Any information that you can give me will be greatly appreciated.

Marion, Ohio. G. R. K.

In answer to G. R. K.'s question in a recent issue, I would advise using 600-volt fuses and cutouts, although there are now some types of switches, fuses and cutouts on the market that can be used for 250 volts d. c. or 440 volts a. c. Personally I always insist on Buss refillable fuses, as they are very reliable and save a lot of trouble. They are manufactured by the Bussman Manufacturing Co., St. Louis, Mo. Single-pole cutouts are used now practically everywhere.

A circuit breaker could be used on the 300-amp. circuit but it is not needed, as nearly all authorities allow 600-amp. on fuses, if the voltage is below 600. I know of several installations that have 1,000-amp. fuses. However, it is good practice to use circuit breakers on 600 amp. or above. Switches and cutouts for high amperages usually have two or more clips and blades, and require several fuses, in parallel.

GRADY H. EMERSON.

Birmingham, Ala.

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Answering G. R. K.'s question in a recent issue, 600-volt fuses are the proper ones to use for this service. This will, of course, require the use of 600-volt switches and fuse blocks, which is only reasonable since the spacing of current-carrying parts of different polarity are much greater in 600-volt than in 250-volt equipment.

In regard to the use of fuses larger than 300-amp. rating, since fuse replacement in the large sizes is expensive, the best practice is to use circuit breakers except where fuses would rarely ever blow. L. T. JOHNSON.

East Cleveland, Ohio.

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Answering G. R. K. in a late issue, there is a little book, not hard to obtain, which will be found to contain answers to many questions on wiring which come up, from time to time, in these columns. That book is known as the "National Electrical Code" and it is the writer's belief that a copy of it should be in the hands of anyone interested in wiring as, without it, many costly mistakes may be made and, even if it is not needed to prevent mistakes, it will give much valuable information in regard to what is considered to be the best standard practice.

In the Code fuses are not rated as "250 volt" or "600 volt," but they are described as being for "Not over 250 volts" and "Not over 600 volts." A 440-volt circuit would, therefore, need what is ordinarily known as a 600-volt fuse.

In his second question G. R. K. asks whether or not fuses above 300 amp. rating are practicable as entrance fuses. Larger fuses are made and are entirely practicable under certain conditions. But the load should be a steady one, never approaching the rated capacity of the fuses which, in turn, should be protected by many smaller fuses in the branch circuits. Under such conditions the main fuses are not liable to blow except from a short-circuit near by or some other unusual condition which would seldom occur.

Where the load is a swinging one with sharp peaks, as in many motor installations and, therefore, a fuse would often be blown, the circuit-breaker would be preferable. This would be true in all cases where the saving in time by closing a breaker, instead of replacing a fuse, is important.

Westfield, N. J. G. H. MCKELWAY.

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Using Vacuum Pump as Air Compressor—I have a Wahl vacuum pump, size 4 in. by 2½ in., with ¾-in. inlet and outlet, which I wish to use as an air compressor. The pressure in the air tank need not go over 125 lb. per sq. in. Will someone please tell me, (1) What size motor would be required to drive this pump at 275 r.p.m.? (2) Will it be necessary to make provision for cooling this pump artificially, by means of air fins or water, in order to keep the temperature down to a safe limit? (3) How do you figure the cubic inches of air compressed per stroke?

Dallas, Tex. R. E. L.

In the March issue R. E. L. asks whether he can use one of our vacuum pumps as an air compressor, to work at a pressure of 125 lb. per sq. in. This vacuum pump is designed to produce a vacuum of 28 in., maximum, and will not stand a pressure of 125 lb., at any speed. While the writer believes that there would be little immediate danger of the pump breaking, the factor of safety used in designing it was not such as to advise a pressure in excess of 20 lb. per q. in., regardless of the speed at which it is driven.

Director of Sales, R. A. KIEFER.
Quincy Compressor Co.,
Quincy, Ill.

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Referring to the questions by R. E. L. in the March issue of INDUSTRIAL ENGINEER, the vacuum pump, with some modifications, can be adapted to be used as an air compressor. The ¾-in. inlet is satisfactory, but the delivery or outlet should be changed to a ⅜-in. or ¼-in. check valve. Considering the bore of 4 in. and stroke of 2½ in., the speed of 275 r.p.m. is high and difficulty may be experienced in the functioning of the valves. At a speed of 275 r.p.m. the pump has a capacity of approximately 5 cu. ft. of free air per minute, and based on continuous duty would require a 1¼-hp. motor, or 1-hp. on intermittent duty. At 150 r.p.m. the capacity would be approximately 2.75 cu. ft. of free air per minute and a ¾-hp. motor would be required. At this speed the efficiency would be much higher and heating lower.

Air cooling through the use of fins or ribbing might be sufficient, although it is somewhat questionable, depending upon how effectively the arrangement can be made. Some artificial means of cooling will be necessary.

In the foregoing I have assumed, of course, that the thickness of the metal and the general design of the pump are such as to allow it to be used at the pressure mentioned in the question.

The volume of free air compressed per stroke is given by the formula: $V=d^2\times0.7854\times S$, where d=bore of cylinder in inches, S=stroke in inches, and V=volume in cubic inches.

Engineering Dept., E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Trouble With Rewound Automobile Generators—I have been rewinding some automobile generators, but in spite of the fact that I always check up the old winding and make the new one as nearly like it as possible I sometimes have trouble in getting the proper amperage out of the generator. The voltage will be up to normal, six volts, but the charging rate is too low. I wish some reader who has had experience in such work would give me some suggestions as to where the trouble may be.

Bathurst, N. B., Can. H. J. M.

Answering H. J. M. in the March issue, if his winding is correct, he may find his trouble in the charging control of his generator, which is dependent on the make and is capable of regulation. This control is often used by the motorist in touring where much of the driving is done in the day time. If H. J. M. wishes to check up on the principles or operation of this control the information can be secured from the manufacturer, the dealer or a garage man.

West Allis, Wis. EDWARD JAMES.

* * * *

In his question in the March issue, H. J. M. says that he can get only six volts out of a generator which he rewound. To charge a six-volt battery on a car requires eight or nine volts from the generator, in order to overcome the voltage from the battery.

The usual reason for generators not having the output they should, is because the throw of the leads has been slightly changed. When an armature is torn down, the top leads should be marked with a center punch where they come out of the slot in the core and the bars that they go into on the commutator should also be marked. The span of the coils should likewise be noted, as well as the bars to which the bottom leads are connected. In some armatures there is what is called a dead coil. This should be put into the same slot that it occupied originally. If the leads do not go back into the same slots in the commutator, the brushes will not set on the correct bars and the generator will not develop its rated output. Owing to the low voltage, a slight change in the setting of the brushes will make a big difference in the charging rate.

The rewound armature should always have the same number of turns of wire in the coils as it had originally. If the winder has difficulty in getting the wire into the slot, owing to a slight variation in the size of the wire, it is better to use a wire one size smaller than to wind the coils with a smaller number of turns.

We have rewound a great number of armatures with wire that was one size smaller than that used originally and we never had any trouble with heating up on that account.

I am inclined to think that his trouble lies in not getting the leads in the right relation to the slots in the armature.

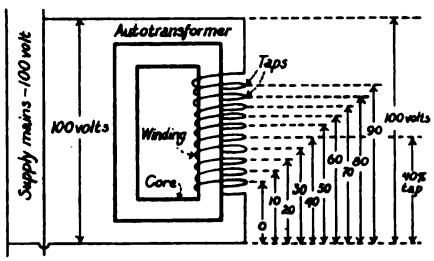
Peoria, Ill. GEORGE D. RINGNESS.

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Calculating Starting Resistance for D.C. Motors—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?
Albert, W. Va. F. H.

To answer F. H.'s first question in the February issue we must go back to the fundamentals of electricity. Assume a 250-volt motor with 0.25-ohm armature resistance, drawing 100 amp. under full load. According to Ohm's law, I=E÷R; therefore, substituting the above values, I=250÷0.25 or 1,000 amp. A current of this magnitude would destroy the machine.

The starting rheostat would have to be designed to prevent this high current flow. If we have a rheostat with 2.25 ohms resistance which, with the armature resistance of 0.25 ohms would give a value of 2.5 ohms, the equation would then be, I=250÷2.50, or 100 amp., which does not exceed the current value of the motor.



Any desired percentage of line voltage may be obtained by taking taps at proper points on the winding of an auto-transformer.

At standstill the armature presents the very low resistance of only 0.25 ohms, but as it comes up to speed it generates a counter-emf. which makes it necessary to cut out resistance as the motor speed increases. When the motor is running at a little more than half-speed, the counter-emf. will be around 125 volts. If the motor attained this speed with all of the rheostat resistance in circuit, it would be drawing only 50 amp. as the rheostat resistance would remain at 2.25 ohms and the internal resistance at 0.25 ohms. Therefore, at this value enough rheostat resistance should be cut out so that there will be only 1.25 ohms in the circuit. Then the equation will be, I= 125÷1.25, or 100 amp. This gradual reduction of resistance is carried out in a number of steps until the motor is connected directly across the line.

It can readily be noted that if the rheostat is cut out too fast the motor will draw an excessive current due to the fact that it has not attained speed enough to generate a counter-emf. in proportion to the applied voltage and the resistance being cut out of the circuit. On the other hand, if the motor is advanced too slowly the starting taps, resistance, etc., will be endangered, as they are designed only for momentary service and not for speed control, which is something entirely different.

With reference to his second question, a compensator is essentially a transformer with only one winding, a portion of which acts as both the primary and secondary winding. Almost any desired voltage lower than the applied voltage can be obtained from it by taking off taps at the proper point. I believe this is made clear in the illustration, which shows an elementary design of auto-transformer, operating from a 100-volt supply and provided with 10 taps from which any voltage from 0 to 90 volts can be obtained in steps of 10 volts.
West Allis, Wis. EDWARD JAMES.

* * * *

Replying to F. H. in the February issue, an auto-transformer or a compensator has only one winding which is wound on an iron core and serves both as high- and low-tension winding.

If connected across a source of voltage the fall of potential along the winding is in proportion to the number of turns and any voltage lower than the applied voltage can be obtained by taking taps off the proper points on the coil.

For alternating-current motors, the compensator supplies a reduced voltage to the motor circuit while the machine is accelerating from rest. Ordinarily, each auto-transformer is provided with several taps so that a number of low voltages may be obtained. Compensators can be adjusted to give 50, 65 and 80 per cent of line voltage with respective line currents equal to 25, 42 and 65 per cent of the current that would be taken by the motor if no compensator were used. In order to keep the starting current as low as possible, it is important to select the lowest taps that will start the load. To obtain full-load torque at starting requires about 80 per cent of normal voltage.
Brooklyn, N. Y. HALSEY DEGRAW.

* * * *

With reference to an inquiry by F. H. in the February issue, calculation of resistance for direct-current motor starting rheostats, when treated theoretically, is somewhat involved. However, the following method will serve for ordinary industrial application in temporary or emergency cases: Compute maximum allowable starting current—this is generally assumed to be from 1.5 to 2 times the full-load current of the motor, depending upon the nature of load to be started. Then employ sufficient resistance between the first active contact point and the last to limit the current to the above value.

Steps should be so arranged that the amount of resistance cut out is less for each succesive step approaching the all-out position. For example, in an exaggerated case the figures for comparative resistance of a starting box from the first to the last step, six points being used, might be given as 15-9-5-1-½-0. The carrying capacity of the resistance element used is also generally increased toward the last steps.

Complete data sheets giving resistance, carrying capacity, etc., can be had from manufacturers of resistance alloys. Driver-Harris Company, Harrison, N. J., will furnish information of this nature.

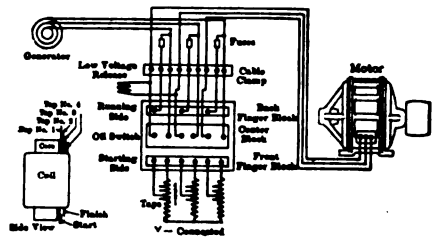
For starting a. c. motors, an auto-transformer is usually employed. Different voltages are obtained by tapping the winding at points corresponding to the desired starting voltage. The usual percentage of these taps, with reference to full-line voltage, is as follows: 50, 65, 80 and 100.
Baltimore, Md. EDWARD H. HAUSLER.

* * * *

With reference to the question by F. H. in the February issue, (1) if full line voltage were passed through the armature of a direct-current motor at standstill an excess of current would flow and cause damage. Consequently, a starting resistance has to be used to limit the current until the counter-emf. has built up to the proper value. The problem then, is to determine the resistance which must be used to keep the current flow down to a safe value.

According to Ohm's law R=E÷I, where *E* equals voltage, *I* equals current in amperes and *R* equals resistance in ohms.

For the application of this law, suppose we have a 10-hp. 110-volt motor which takes 90 amp. when fully loaded. The armature resistance is 0.05 ohms.



Internal and external connections of auto-starter for alternating current motor.

What value of starting resistance should be used, assuming that the starting current is to be 100 amp.?

From the above equation, R=110÷ 100=1.1 ohms. The resistance of the armature is only 0.05 ohms so that the starting resistance will have to be 1.1-0.05=1.05 ohms.

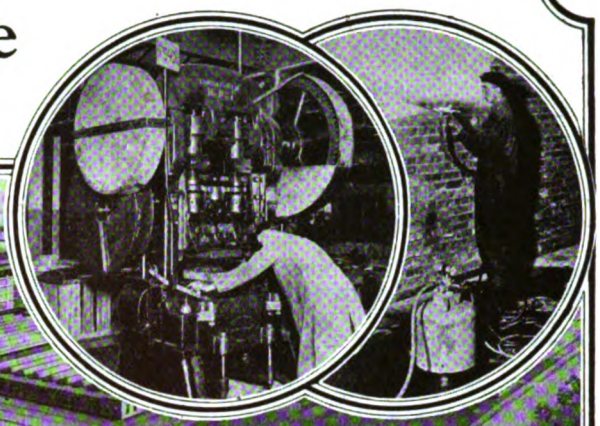
In a series motor, the field is in series with the armature and, therefore, its resistance must be added to that of the armature when making the above calculation. In the case of a compound-wound motor, the same allowance must be made as for a series motor.

(2) The diagram shows how the different taps are obtained and the auto-starter and motor are connected. The coils of an auto-starter are nothing more than an auto-transformer connected star. The coils are connected directly across the line when the motor is started. The lower starting voltage is obtained by means of taps taken off at different points on the windings. Usually three values of voltage are available. The first tap gives a voltage of 40 to 50 per cent of the line voltage; the second tap gives from 65 to 70 per cent, and the third tap gives about 85 per cent. The selection of the proper taps depends upon starting conditions. If the motor has to start under heavy load a tap giving a higher voltage value is chosen. Conversely, a lower-voltage tap is used if the motor does not have to start under heavy load.
Brooklyn, N. Y. MICHAEL REUTER.

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Building Maintenance and Plant Safety





The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Special Saw Rigged Up to Cut Out Wooden Flooring

CUTTING out wood flooring for the placing of new machinery on a concrete base, proved a slow and difficult operation in one industrial plant until the circular saw shown in an accompanying illustration, was put on the job. This saw is driven by a portable electric drill mounted on a special carriage consisting of a two-wheel tote truck, such as is ordinarily used for hauling small tote boxes around the plant. This truck may be purchased at a cost of $3 or $4 from almost any mill supply or machinery house.

In attaching this saw, two holes are drilled in the frame of the tote carriage, through which two screws are run into the regular tapped holes in the top head of the electric drill. The other end of the electric drill is supported by a board. The spindle housing of the drill fits snugly into a hole, which is drilled in the approximate center of the board. One end of this board is held firmly by slipping the axle of the tote carriage through the end; the other end is supported by the two bolts ordinarily used to hold the frame to the handle of the tote carriage.

The drill in the illustration is a ⅜-in. capacity electric drill (The Van Dorn Electric Tool Company, Cleveland, Ohio) on which the chuck is threaded to the spindle by a right-hand thread. As the diameter of this spindle is ½ in., an 8-in. diameter saw with a ½-in. hole is used. To attach the saw, it is simply necessary to unscrew the chuck from the spindle of the electric drill, slip the saw onto the spindle and use the regular, threaded back chuck to hold the saw in place.

The outfit shown in the illustration was used to cut out wood flooring 2 in. thick. A similar operation is frequently encountered in many plants when it is desired to remove a portion of the flooring in order to permit the mounting of heavy machinery on a concrete foundation or when it is desired to remove sections of the flooring for repairs. With this outfit a neat job with a good straight edge can be obtained, and there is not the tendency to split some of the flooring that is not to be removed, as is the case when some other methods are employed. For example, one of the common methods used to remove flooring is to drill holes at the four corners of the section which it is desired to remove, and then use a hammer and chisel.

An electrically driven saw of this sort does the work in about one-fifth the time usually required by hand. It would not take many such jobs to make it pay for itself.

Rules Governing Fire Prevention in Industrial Plants

PREVENTION of fires in industrial plants is largely a matter of painstaking care in the avoidance and removal of the conditions which cause fires. In many plants the primary causes of fires are not recognized or considered and there are no clearly defined regulations or inspection which will safeguard the property.

Observance of the regulations given below is essential to any fire-prevention program. They embody precautions which apply generally to any manufac-



With this special carriage and saw wooden flooring can be cut out in about one-fifth the time ordinarily required.

In addition, the saw does a much cleaner job. This outfit can easily be made up by using a portable electric drill, a saw and a small truck for tote boxes. This truck can either be purchased, or made at small cost.

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turing establishment and represent a thorough consideration of the ordinary causes of fires as shown by reports over a long period of time in several plants.

Fire Prevention Regulations

1. Fire hydrants, extinguishers, hose, and other firefighting equipment must be kept clear of obstructions at all times, in order to permit quick and convenient access to them.

2. Defective wiring, leaky steam pipes, etc., must be immediately reported to the superintendent.

3. Putting overalls or other greasy clothing, waste, etc., in lockers is prohibited.

4. Hanging clothing, towels, or cloth material of any kind on steam pipes or close to exposed electrical wiring is prohibited.

5. Electrical work is to be done only by the employees of the electrical department. Unauthorized lights, fixtures, inflammable shades, etc., are prohibited.

6. All electrical switch and panel cabinets must at all times be kept closed. In case temporary connections have to be made, such cabinets must be closed as completely as possible without injury to such temporary connections.

7. Forges, open lights, and fires must not be left unattended, and must be extinguished before closing time.

8. Before closing, all buildings must be cleared of inflammable refuse, and trash cans emptied or taken outside. Material such as waste, oil, etc., must be kept in the proper receptacles provided for that purpose.

9. Unduly high temperatures in buildings must be investigated and reported at once to a foreman or the superintendent.

10. Unslaked lime and all inflamable materials must be kept only in places designated by the superintendent.

11. Smoking in the plant is prohibited, except at such times and places as permitted by the superintendent. Safety matches only may be carried or used in the plant.

12. An inspection of all buildings and fire apparatus will be made every two weeks by an employee designated for this purpose by the superintendent and a written report of each inspection will be made.

Washington, D. C. G. A. LUERS.

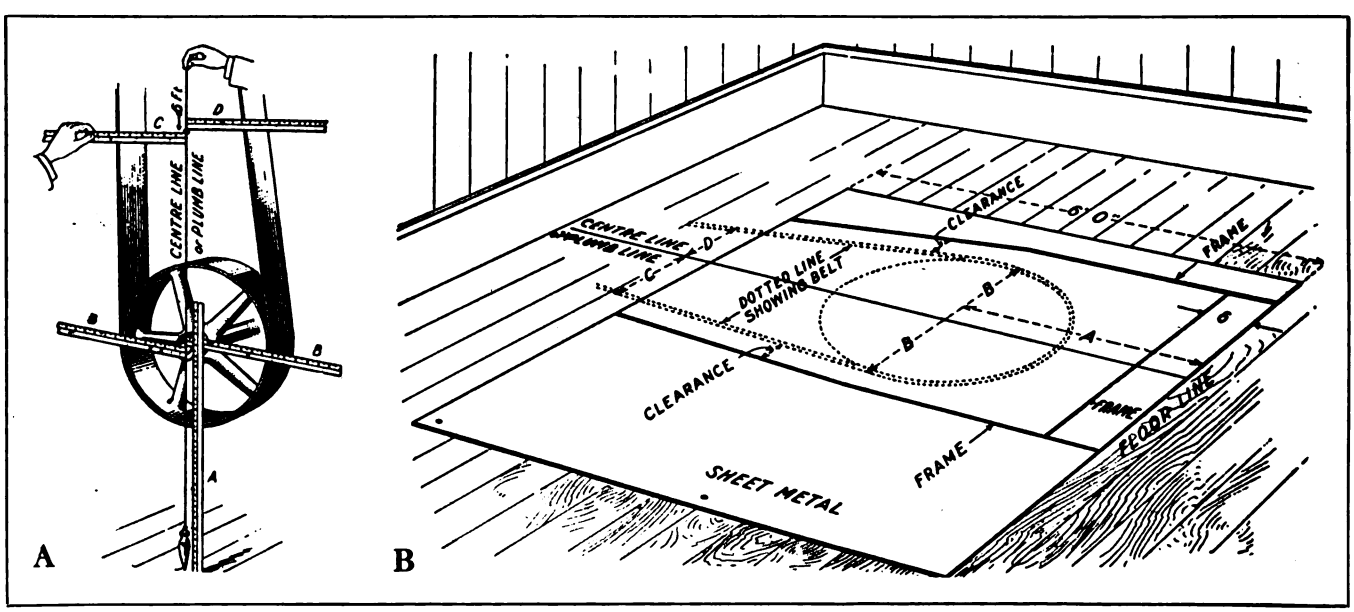
One Way to Take Measurements and Lay Out Machine Guards

WHEN making guards for industrial machines, perhaps the first point to take into consideration is to make sure that they conform with any state or insurance regulations. These cover the type of guard to be used, the size, clearance and other requirements of the object which must be guarded. In addition, two other important points must be considered. These points cover the rigidity of the guard and also the workmanship. To make a guard rigid requires that it be made of the proper material and be properly braced. Workmanship also affects the rigidity of the guard as well as its appearance. Other important factors affecting appearance are the care and accuracy exercised in laying the guard out properly.

Suggestions for measuring an installation and laying out the guards are given by the Consolidated Expanded Metal Companies, Braddock, Pa., for guards made of "Steelcrete," an expanded metal. While taking these measurements is one of the most important, it is also a simple operation in the construction of machine guards. The method of taking these measurements is shown in *A* of the accompanying sketch. In this a knot is made in the plumb line at a point 6 ft. from the tip of the plumb bob. This is held so that the tip of the plumb bob touches the floor and the line passes through the center of the pulley shaft. This plumb line then becomes a center line and from it all essential measurements as indicated are taken in both directions.

In laying out the guard, these measurements are first transferred full size on to a plain surface. One method of doing this is shown in *B*. A good, practical drawing surface may be made by fastening a few light-gage black metal sheets to the floor. A vertical line corresponding to the plumb line is used as a center line and the various measurements obtained in *A* are drawn out on this sheet metal. The necessary clearance as required by state factory or insurance inspection rules is then added and the outline of the guard is then drawn in. These outlines are most easily drawn in with a soapstone pencil. The expanded metal can then be laid on top of this drawing on the floor and trimmed to the proper size, or the lines upon which the metal is to be cut marked on the expanded metal and then cut by a shears or by other means. It is customary to build one side of the frames of the guards at a time. The angle iron is cut, bent, and fitted exactly to conform to the outline. The expanded metal after it is cut to size is then fitted and fastened to the angles.

Ordinarily, state or insurance regulations specify that guards for such drives as shown at *A* need be only 6 ft. from the floor, as that is considered high enough to prevent accidental injury. By far the largest item in the manufacture of guards is the labor involved. Ordinarily, the cost of material almost regardless of the kind or quality, will not be more than 15 or 20 per cent of the cost of the finished guard. For this reason, it is always an advantage to get a good grade of material and when spending the money for workmanship to see that only the best is put into it. A rough, unfinished guard is not only unsightly but may be unsafe.



Steps in taking the measurements and laying out a machine guard. The pulley and belt are measured with the aid of scales and a plumb line, as shown at the left. These measurements are then transferred to black sheet metal placed on the floor. After drawing the outline of the machine and adding the clearances, the outline of the guard is then drawn in and used as a templet for laying out the guard and the angle-iron frame.

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Method of Making a Tripod From Conduit

A TRIPOD that will handle up to 1,500 lb. and which may be made from conduit, has been found very handy around our plant for making lifts over small machines that are not reached by the traveling crane. The legs of the tripod are made from three pieces of 1¼-in. conduit, each piece being 9 ft. long. Flatten one end of two of the legs for a distance of about 2 in. and bend the ends out a little. The third piece should have one end flattened for a distance of about 6 in. A ⅝-in. hole is drilled through each of the flat ends. The three flat ends of the conduit, together with a clevis about 6 in. long are then bolted together by means of a ⅝-in. bolt.

To the bottom end of each leg a pointed 1¼-in. solid rod is welded. This is done to prevent the tripod from slipping when it is set up. The chain block or block and tackle is hooked on to the clevis which is at the top of the tripod.

This tripod can be quickly set up over any part that has to be lifted. It will be found that one man can handle it easily. Also it can be folded together and put in the shop when not in use.

Chief Electrician, W. B. CONE.
Shevlin-Hixon Company,
Bend, Ore.

Comparative Costs on Three Types of Factory Floors for Trucking Runways

AFTER many years of experience on floor maintenance, I have decided that for our work the best material for trucking runways and for floors for heavy work, is the creosoted wood block. For several years I have experimented with different mixtures of concrete and surface hardeners, but my experience has been that the concrete did not stand up under our requirements. Certain spots seem to wear faster than others, small depressions result or cracks develop, and these soon grow into holes.

Furthermore, concrete does not lend itself well to any patching process. The patch is seldom a perfect bond with the old concrete and a crack usually develops at the bond. Another cause for the patch not standing up, is that the surface of the patch is new and hard, with a skin on it. The old concrete has the surface or skin fairly well worn off. Where the truck wheels move from the surface of the old concrete onto the surface of the new, there is a very slight bumping action which soon develops a depression at this point and as the truck leaves the patch the same thing is repeated and eventually gives two bad spots instead of one. No doubt, in some plants where the trucking is not severe, the concrete might show up better, but the trucking in our plant is extremely severe.

The plank type of runway is, I believe, to be preferred to concrete and has some good points but, unfortunately, several bad ones, also. I have obtained the best results with the planks laid so that the traffic was with the grain. This stands up well and is cheaper to install and to repair. It is better to lay the plank in the longest lengths obtainable as the less joints the better; trouble usually occurs first at the joints. Wood planks have the advantages of being dustless, noiseless and easy to repair, and the disadvantages of wearing rapidly and unevenly, and eventually splintering. Foot injuries often result when splintered wood runways connect up with a pair of badly-worn shoes. In some lines of manufacture, particularly rubber products, these splinters manage to get into the product and may cause serious trouble and complaints.

Cost Per Year of Factory Floors

Type of Flooring	Useful Life	Cost per Sq. Ft.
Concrete	8 years	4.1 cents
Hardwood plank	8 years	3.8 cents
Creosoted wood block	30 years	1.7 cents

Because of the disadvantage of concrete and plank flooring, I believe that the creosoted wood block is, all things considered, the best for our work and am using a 2½-in. by 3-in. by 7-in. block, 8 lb. treatment. These blocks when installed in runways on the ground floor of the plant, are set as follows: The foundation consists of 4 to 5 in. of well-rammed concrete, leveled off fairly well on top. The top of this concrete is finished off at such a depth as to allow for the thickness of the blocks and from ¼ in. to ½ in. of sand cushion.

After the concrete is well set, it is covered with a layer of lake sand, not too fine, and this is leveled off very slightly higher than the thickness of the blocks below the surrounding floor level. The blocks are then laid in place, end grain up, and driven tightly against each other. If the edges of the area cut out for the runway are uneven, (if in a concrete floor), pieces of 2-in. by 3-in. plank are laid along the edge and held in place by cross pieces which are removed as the work of laying the blocks progresses. These serve the purpose of a straightedge to lay the blocks against. After all the blocks are laid, they are covered with lake sand; this is swept well into the cracks between the blocks and then the whole surface is well tamped. The side pieces, serving as straightedges, are then removed and any openings left are filled with concrete. This finishes the runway straight and flush with the floor.

If the block runway is being laid in a plank floor, the edges of cut out area for the runway can be made straight and true without any trouble. We have had little need to use wood blocks on floors other than the ground floor, but it is entirely feasible. Our trucking on floors other than the ground floor is fairly light and tongue-and-groove hard maple, ⅞ in. thick, has been reasonably satisfactory when laid so that the traffic was with the grain.

Creosoted wood block is not expensive when its life is taken into consideration, although the first cost is higher than most types of flooring. The first cost is practically all the expense as the repairs for many years are nil. Our actual cost on the wood-block runway is 53 cents per square foot laid for the 2½-in. by 3-in. by 7-in. blocks. Of this amount, 28¼ cents covers the concrete foundation and laying of the blocks; the balance represents the net cost of the blocks. This cost would, of course, vary considerably according to the location of the plant. The cost of the material would be lower in the United States than in Canada, but the labor cost would be higher.

An estimate of the actual life of the wood-block runway would be about 30 yr. based on the following: Several tests were made on the busiest runways in our plant at points where the heaviest traffic is experienced, and after two years of service the maximum wear shown on the blocks was only 1/16 in. At exactly the same location, in a previous test on wood plank, the wear at the end of two years was ¼ in., or four times the wear on the blocks. Tests also showed that nominal 2-in. hardwood plank will, under heavy traffic, be reduced to 1 in. and less in thickness in eight years and is then in a dangerous condition.

A wood-block runway of 2½-in. blocks has the advantage of the additional thickness over the plank for extra wear. Also, if the blocks become too badly worn for easy trucking, they can be taken up without damage, more filling put under them, and releveled. With the plank floor it is necessary to turn it and it is nearly impossible to make a good job, because the planks nearest the sides of the runway are often not worn so much as those in the center and require a lot of shimming up and fitting. With the blocks, the ones at the edges which are not worn so much can be placed in the center when resetting and the worn ones placed to the edges; the difference in thickness is taken care of with the sand fill underneath.

The wood blocks are not dusty and are quiet. As they are end-grain, they have very little tendency to cut into ruts, especially as the directions of the end grains are mixed up considerably. Wood blocks are easy to patch and if a runway is changed in location, there is little waste in taking it up and moving it. In such a case the space left vacant by its removal can be filled solid with concrete; if located in a wood floor, stringers can be set in and a regular floor laid. Another favorable feature of the wood-block runway is that on account of the size of the blocks they can be laid to follow any inequalities in the floor level without any trouble. This, of course, can also be done with a concrete runway, but is a very troublesome problem sometimes with a plank runway, especially in old floors.

The actual costs of the three different types of runways mentioned in this article have worked out with us as shown in the accompanying table. This is based on cost per year, per square foot.

Some of the readers of INDUSTRIAL ENGINEER may not agree with me regarding this, and I would be interested in seeing some discussion along this line.

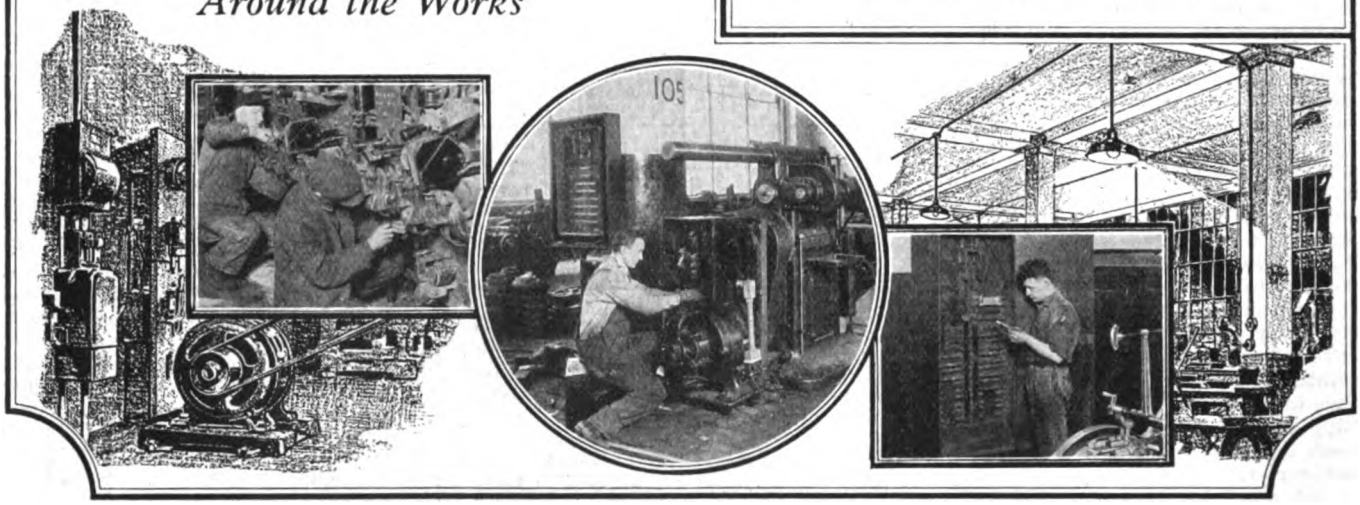
L. J. CLAYTON.
Assistant Mechanical Engineer,
Goodyear Tire & Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Comment on "Paralleling of Alternators Coupled to Same Shaft"

THE following interesting comment on the short article by R. S. Huntington, which was published under the above heading on page 153 of the March, 1925, issue of INDUSTRIAL ENGINEER, has been received from Mr. Carter of The Baylis Company. His suggested method of doing the job, together with Mr. Huntington's comments thereon, are given below.—EDITORS.

* * * *

In the method used by Mr. Huntington, the bolts were removed from the coupling connecting one alternator with the water wheel and the coupling tied together with cords strong enough to permit the alternators to be brought up to speed by the water wheel. Simple as this method was, I believe it could be simplified by omitting the tying together of the couplings. If the coupling were disconnected, the fields of both machines fully excited while they were standing still, and the switches paralleling the two alternators closed, when the water wheel was started, the generator, which is coupled to the waterwheel, would bring up to speed the uncoupled alternator as a synchronous motor. The field could then be adjusted and the coupling marked as described in the article mentioned.

Engineer, EDWARD D. CARTER.
The Baylis Company.
Bloomfield, N. J.

* * * *

I have read Mr. Carter's comments with interest. His suggestion is all right provided an independent source of exciting current of the proper voltage is available before the waterwheel is started. In the case mentioned in the article, however, the only exciter in the plant was coupled to the same shaft as the waterwheel and, therefore, no direct-current excitation was available until the waterwheel was running at a little better than half-speed.

The method of tying the couplings together with a piece of string was adopted as the simplest and safest method available for getting the uncoupled alternator up to speed in such a manner that the strain would be at a minimum when excitation was applied.

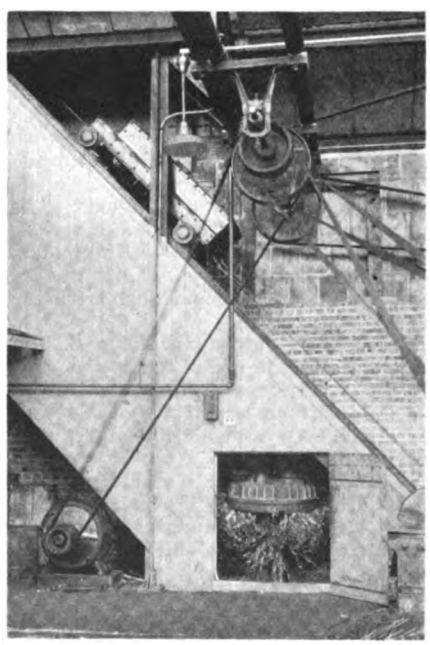
President, R. S. HUNTINGTON.
Huntington & Guerry, Inc.,
Greenville, S. C.

How a Lifting Magnet Is Used to Handle Steel Scrap

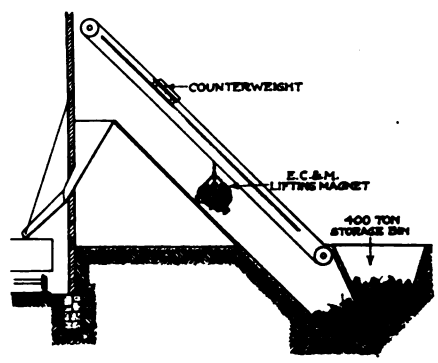
REMOVING and loading scrap upon railway cars is a troublesome problem in many industrial plants. This, however, has been satisfactorily solved at the Chicago, Ill., plant of Harrington & King Perforating Co., who are manufacturers of perforated metals for industrial screens and other purposes. As practically every production machine turns out scrap, a very careful study was made when the layout of their new plant was being drawn up, to determine the best means of handling and disposing of this material.

Now the scrap steel, as it accumulates, is carried to a 400-ton storage bin below the floor level at one end of the main building. To load the scrap from this bin into gondola cars, which are spotted just outside the building, the hoist shown in the accompanying diagram was constructed. This hoist is much on the order of a skip hoist, except that the skip has been replaced by a No. 3 E. C. & M. (The Electric Controller & Mfg. Co., Cleveland, Ohio) magnet. This magnet is suspended from a 45-deg. track which runs from the hopper below the scrap bin to a chute which has a spout dropping over a gondola car on the adjoining track. To cut down the power necessary to operate this system, the magnet is balanced by a counterweight which moves in a direction opposite to that of the magnet. The loaded magnet is driven through a friction drum by a 10-hp. E. C. & M. motor.

When the magnet is in its lower position, where it is resting on the scrap in the hopper, the current is turned on



This view shows how the magnet conveyor system for handling steel scrap is enclosed for safety. The door provides a means of inspecting the operation of the conveyor.



This diagrammatic sketch shows the arrangement of a skip hoist with a magnet for handling scrap steel.

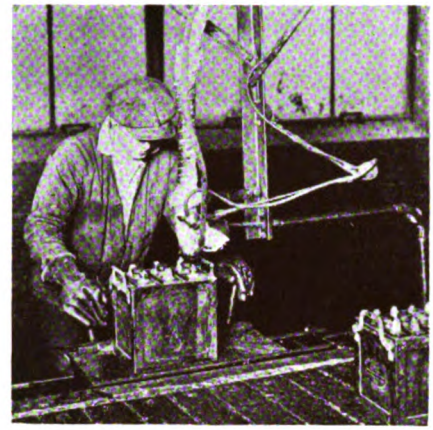
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and the magnet picks up a load of scrap. The operator then runs the magnet up above the loading chute, the magnetizing current is turned off and the load is dropped. By this unique arrangement, 20 tons of scrap an hour can easily be loaded. This means that with 62 trips in an hour, the magnet is averaging over 650 lb. per lift. In addition to reducing materially the handling cost on scrap steel, the company is receiving an additional $2 per ton for the scrap when delivered to the car instead of in the yard.

Application of Space Heaters in Battery Manufacture

HEATING the compound used to seal the covers into the cells of automotive storage batteries has always been a problem. For this compound to work best, the temperature must be maintained constant within a variation of 8 deg. or 10 deg. F. The heat conductivity of this material is so low that a hot plate under the kettle is extremely inefficient and slow, and, as this material is highly inflammable, open flames of any kind would be very dangerous.

This, and other similar problems, were solved about four years ago at the Westinghouse Union Battery Co., at Swissvale, Pa., by some unique applications of standard electric space heaters. As an example, for heating the sealing compound, space heaters were clamped solidly against the sides and bottoms of the compound tank and the tanks and heaters were then covered with sheet asbestos. The pipe which leads from the tank to the nozzle of the sealing machine, as shown in the accompanying illustration at the top of the page, is heated by passing a current of low voltage and high amperage through it. A thermo-couple that actuates a relay is inserted in this pipe near the nozzle.



The manufacture of storage batteries is simplified by the use of electric heat.

One of the big problems in the manufacture of storage batteries is to get the sealing compound to flow down into the battery through the pipes and seal the covers on to the cells. Space heaters, as described in the text, keep the compound warm in the melting tank and special arrangements to heat the pipe facilitate the pouring.

This relay, in turn, opens and closes the circuit leading to both the space heaters and the feed pipe, and so keeps the temperature well within the desired limit.

Another bothersome heating problem was in connection with the manufacture of soft metal storage battery grids. The grids have a light cross-section and are cast in metal molds. The illustration at the bottom of the page shows the workman closing a mold preparatory to casting. A pile of grids is shown at his right.

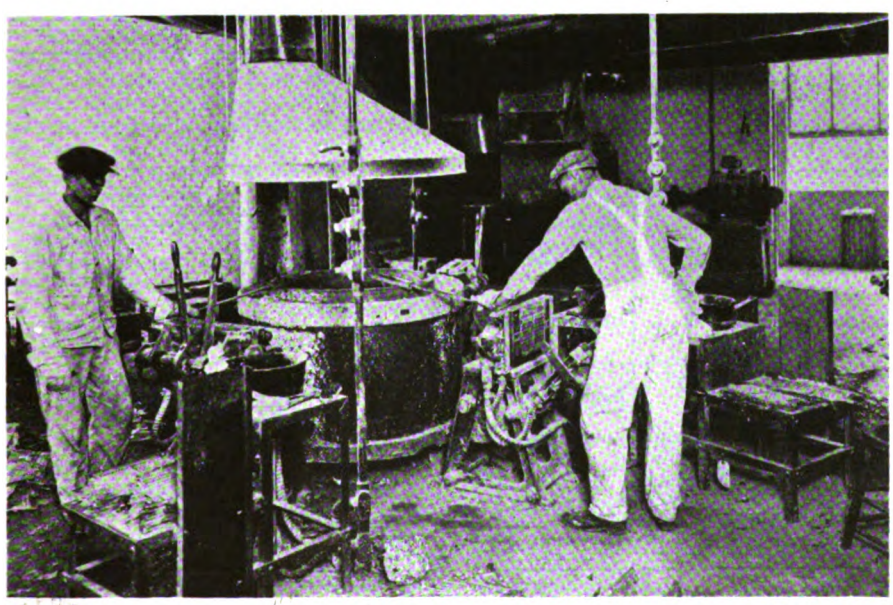
Unless the molds are at exactly the right temperature it is impossible to get good production of perfect grids. When an open flame was used to heat these molds, it was difficult to get the correct temperature; also the open flame was somewhat dangerous. Now, space heaters give the right sort of heating conditions. Three heaters are clamped on each side of the mold. These are connected in opposite pairs so that the operator can control the temperature of any part of the mold by means of a switch. No attempt is made to do this automatically because molds for different grids require different heats. Pilot lights indicate to the operator which pair or pairs of heaters are working at any time.

Electric heat is also used for lead pots, and for melting small quantities of lead, solder and other materials in various departments. In another department the application was in connection with the manufacture of long strings or "worms" of sealing compound about ¼-in. square. These squares are used cold and are extruded from a press. It was found that the press could not handle the cold compound well; so a pair of space heaters was clamped on the outside. These warm the press just enough so that the compound flows out of the press, at the proper consistency for use. Electric heat has been found very useful because of its safety, flexibility, and ease of control in many of these operations.

Production Engineer, P. E. NORRIS.
Westinghouse Union Battery Co.,
Swissvale, Pa.

By means of space heaters these molds are kept at the proper temperature for pouring the lead grids.

Unless these molds for casting the grids for storage batteries are at the proper temperature, the grids do not cast well. To remedy this three electric space heaters are clamped on each side of the mold. These are connected in opposite pairs so that the operator can control the temperature easily through a switch.



Simple Method of Interlocking the Control of Coal-Handling Equipment

COAL-HANDLING equipment for a small power station consisted of a pivoted-bucket carrier, which was used in conjunction with a rubber belt conveyor and a coal crusher. Coal was brought by rail in gondola cars to the power station where it was dumped into a hopper which led to the rubber belt conveyor. The belt conveyor carried the coal to the pivoted-bucket carrier, which in turn carried the coal to the top of the boiler house where it was fed directly into the coal crusher. These three machines were driven by separate motors. To prevent the coal from piling up in case one motor should stop, it was essential that all motors between this motor and the point where coal was received should shut down simultaneously.

It was found that this could be very easily accomplished by using standard General Electric enclosed across-the-line starting switches, type CR-7006-D5, and electrically interlocking them. This magnetic switch consists of a three-pole contactor, an extra pole which is provided for use as an electrical interlock, and a two-coil, hand-reset temperature overload relay. The relay has two heating elements, one connected in each of two phases, so that it provides full overload protection. After the overload relay trips due to an objectionable overload, the contact must be reset by a resetting device operated from the outside of the case.

The starting switches are ordinarily operated by means of a start-and-stop push button station. In case a con-

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tactor opens due to failure of voltage it will not close automatically on return of voltage, but the start button must be pressed in order to restart the motor. Also, in the event of an overload causing the contactor to open it is necessary to reset the relay by hand before pushing the start button to start the motor.

Three of these starters were connected up as indicated in the accompanying diagram. It will be noticed that for the crusher motor the standard scheme of connection was used. The pivoted-bucket carrier motor and the belt conveyor motor were also connected up in a similar manner but, in addition, single-pole, double-throw snap switches were wired into the control circuits of the operating magnets of these two starters. Also, control wires were connected from one pole of the snap switch to the three-pole contactor of the adjacent starting switch, as is shown in the diagram.

For normal operation, both of the single pole, double-throw snap switches are closed as shown in the diagram. With this connection it is only necessary to push the start button of the crusher motor to start all of the motors. The sequence of operation is as follows: Pushing the start button on the crusher motor, closes the three-pole contactor starting this motor. As soon as the three-pole contactor of the crusher starter closes, power is supplied over the control wire to the operating coil of the pivoted-bucket carrier motor which, in turn, starts this motor. As soon as the three-pole contactor of the pivoted-bucket carrier starter closes, power is applied to the operating coil of the belt conveyor motor starter which causes it to function, starting the belt conveyor motor. Hence, it is seen that with this arrangement the pivoted-bucket carrier motor and the crusher motor must always be running before the belt conveyor motor can run and thus there can be no piling up of coal at any point in the system, due to the stopping of a motor.

If it is desired to stop the motor, the stop button on the crusher motor may be pushed which will shut down all motors or the snap switch on either of the other two motors may be turned which will shut down that motor. If the snap switch on the pivoted-bucket carrier motor is turned, that motor as well as the belt conveyor motor will be stopped. If the snap switch on the belt conveyor motor is turned, the belt conveyor motor only will be stopped, thus preventing piling up of coal anywhere in the system, should a motor be shut down.

When the snap switches are thrown to the position shown by the dotted lines in the diagram, the particular motor to which this snap switch applies is cut out of the interlocking sequence and can be operated independently by means of the start-stop button for testing purposes.

ROGER F. EMERSON.
Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

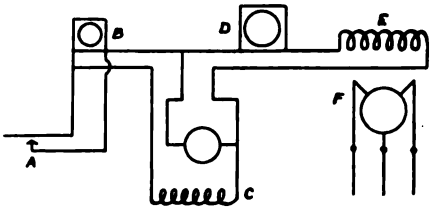
Diagram of connections for interlocking the sequence of starting and stopping of motors.

This control scheme was installed for controlling the operation of three motors driving the coal-handling equipment in a small power plant. To prevent piling up coal at any point it was essential that the crusher motor be running before the pivoted-bucket carrier motor was started. Likewise, it was necessary that the pivoted-bucket carrier motor be running before the belt conveyor motor was started. The control scheme shown in the diagram made the control of the motors follow this sequence.

How an Improvised Method of Regulating A. C. Voltage Kept a Plant Going

RECENTLY, it was necessary for an industrial plant to commence operations before the arrival of a voltage regulator. Since the load fluctuated rapidly and it was found impossible to regulate by hand, using the rheostats, the method shown in the accompanying sketch was devised. An ordinary telegraph key was connected across the terminals of the exciter rheostat so that when the key was closed the resistance was cut out, and when the key was opened resistance was introduced into the exciter field circuit, as shown.

In operation, the exciter field rheostat had its resistance all cut in, while the main rheostat in the alternator field circuit had its resistance all cut out. If the main resistance was cut in, excessive sparking took place at the telegraph key contacts, heating up the key and making it uncomfortable to operate. When the key was closed the voltage rose and when it was opened the voltage fell.



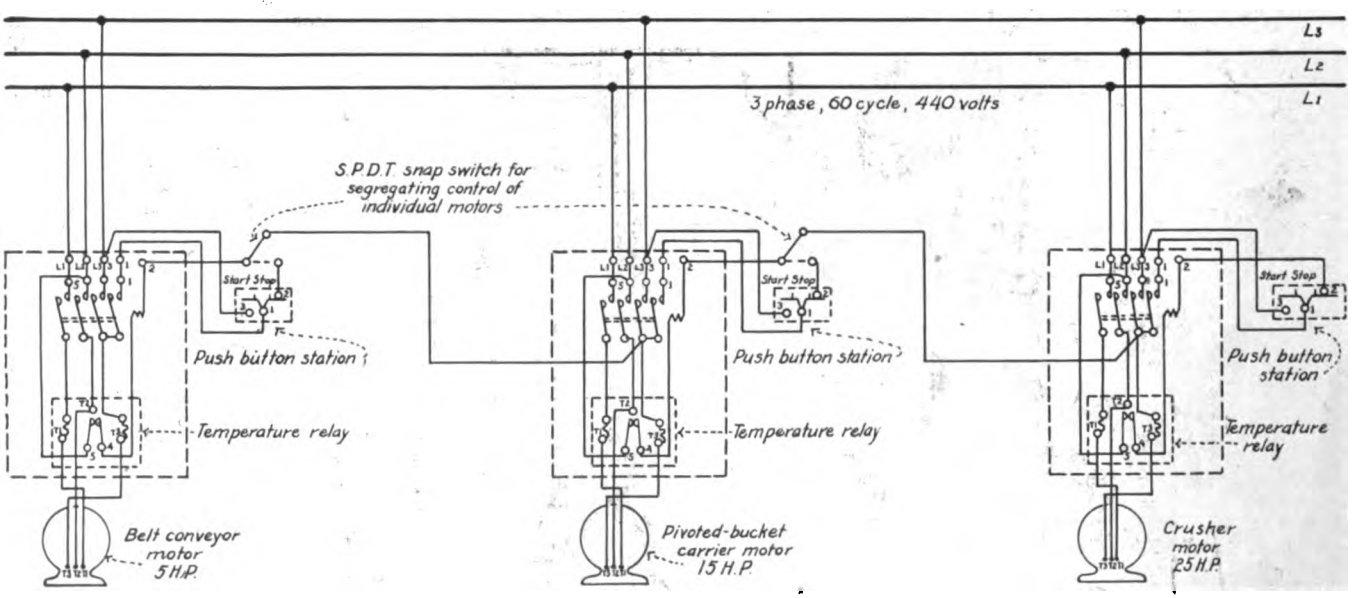
This emergency scheme maintained constant voltage on an alternator and prevented a plant shutdown.

In the diagram *A* is a telegraph key; *B* the exciter field rheostat; *C* the exciter field; *D* the alternator field rheostat; *E* the alternator field and *F* the stator winding.

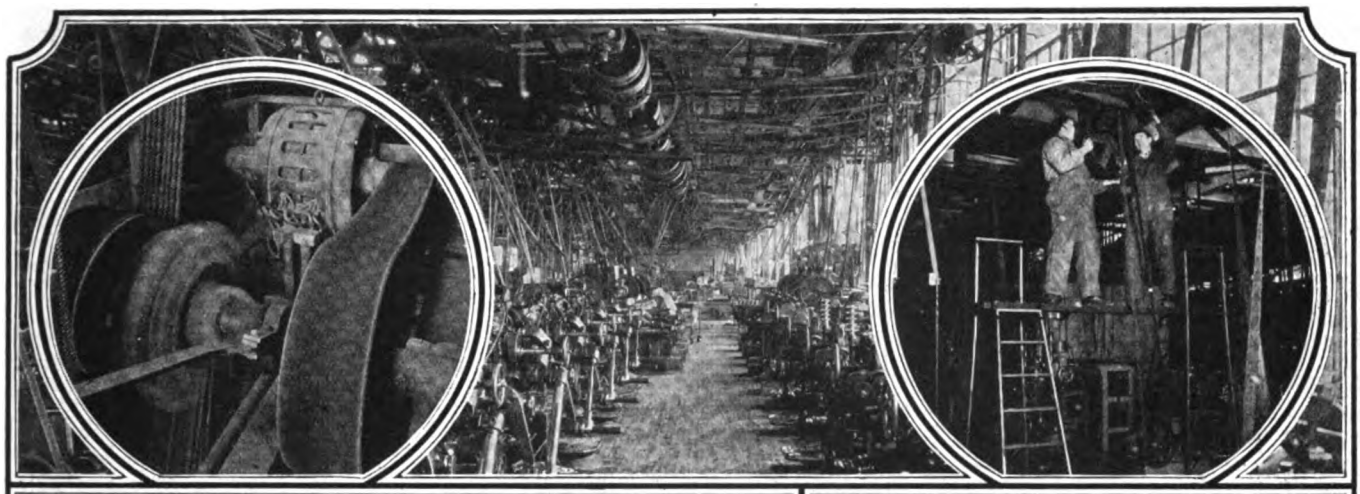
The telegraph key was mounted upon a table in front of the switchboard, so that the voltmeter could be watched, and one of the helpers was detailed to operate it. By this means the voltage was maintained constant during the working hours when the large machines, such as sizers and cut-off saws, etc., were running. At other times it was maintained nearly constant by changing the rheostat arm positions for various loads, such as lighting and wood planers which carried a steady load.

In this way several important orders were saved and the plant kept in operation until the arrival of the voltage regulator.

W. L. STEVENS.
Construction Engineer,
Smith Robinson Co.,
Vancouver, B. C.



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Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

How Frozen Motor Bearing Was Removed and Repaired

ALONG about ten o'clock one morning our motor began to slow up and shortly stopped altogether. Fuse tests showed that we had power right up to the machine. When we tried pulling on the belts we discovered, however, that something was stuck. This was finally traced to one of the bearings on the 30-hp. Westinghouse induction motor, and we couldn't budge the thing. Investigation showed that the oil ring had jumped and landed on top where it stayed high and dry; it was a motor that was not yet equipped with oil ring retainers but this was the first time in five years that we had had any trouble.

A fine fix that was. A frozen bearing tied up the whole shop and there was no other machine shop within ten miles! We were about to dismiss the men for the day, for more than half of them were doing actual machining operations, when the foreman offered to retain six men to do the repair job and find hand work for the remainder of the machine hands.

Quickly dispatching three of the men to preliminary work, he took the other three to the job of getting the bearing free from the shaft. That proved to be more of a task than had been anticipated. The motor head was of cast iron, of light ribbed form, and would not stand much of a stress; that made it harder to put any pressure on it to help pry the bearing along the shaft, and the possibility of a complete tie-up if we lost the motor head made us more than careful. If the head were pulled off the bearing, leaving the latter stuck on the shaft, there was no way to get behind the bearing to press or drive it off.

In the end, we attached a piece of flat bar stock to the motor head by clamps and bolts. This gave us a lever 10 ft. long which we used to free the bearing from the shaft and, very slowly, we were able to free it enough to move it along and off. All the while we were afraid that the set screw let into the bearing from the head would shear off, but it didn't.

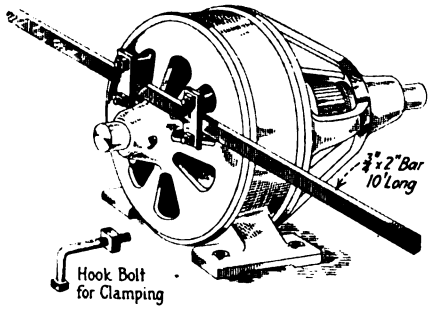
Meanwhile the men detailed to other parts of the job had a lathe ready to bore out the bearing, had a fire and the babbitt hot, and had prepared a mandrel and a set-up to re-babbitt the box. The old babbitt was melted out, and the new metal was soon solidifying in its place. One of the gang had already smoothed off the shaft and found it to be unhurt.

The best lathe hand was given the job of chucking the newly babbitted piece and boring it out. But how were we to bore it out when the only power in the place was gone?

The foreman had supplied the scheme, which was to use human power, and he had provided well for it. There were now five men from the job who were waiting around and these five were formed in line in front of the lathe, to pull the belt. This they did with a will. It became a sort of game and as fast as one man dropped his arms in sheer exhaustion, the next in line took his place and followed suit. Actually, this man-power was almost as speedy as electric drive would have been and the man who took the cuts found he had little time between them, the boys really making him hustle and taunting him with his lack of push.

In this way, the bearing was made ready for use. Oil grooves were cut and it was replaced in the head, after checking the fit by trying it first on the shaft. The motor was assembled and the machinery started again in a little less than five hours. The cost to us was about $25, but that was only a trifle of what it would have been but for the bright idea of the foreman.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.



The oil ring jumped out of place and the bearing froze.

A ¾-in. by 2-in. bar 10 ft. long was clamped to the end bell with hook bolts as shown. Two men carefully turned and pulled at the bar until they worked the head off and brought the frozen babbitt bearing along with it. More heroic methods might have broken the end bell. How the problem of boring out the bearing when no power was available, was solved, is given in the accompanying item.

Why Shafts Peen Under Inner Rings of Ball Bearings

IN THE case of belt-connected motors, there is sometimes a tendency toward a shaft-peening action under the inner rings of ball bearings. This is particularly noticeable when a belt is laced instead of being made endless with a cemented joint. The repeated shock on the driving pulley, which is transmitted to the bearing as the belt lacing strikes the pulley will, unless ball bearings are very carefully fitted, start this peening action under the bearings. The same action is started in a gear drive connection when one or two teeth are broken so that a similar shock occurs when these points of the gear engage and let loose.

A well known ball bearing manufacturer states that this trouble can be overcome by the use of a wide inner ring with a width equal to its bore. The advantage claimed for this greater width of inner ring is that the extra width affords the shaft proportionately greater support to resist vibration. At the same time the mounting is kept much more compact and the inner ring

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does not require such a close fit on the shaft. In this way the danger of expanding the inner ring and cramping the bearing is avoided.

Getting More Power at the Die of Punch Presses

OCCASIONALLY a shop needs to get more work out of a punch press than it is designed to turn out. Usually manufacturers have put ample strength into the machines for their flywheel size and speed and this excess permits a certain amount of crowding to be resorted to on special jobs. Again, in case an executive is hard pressed he may be willing to take a chance on strength to get work out.

The commonest way to get more powerful strokes is to speed up the machine. A full knowledge of safe rim speeds for cast-iron wheels should precede such a change. As the available power is increased as the square of the speed, a slight change will often give the desired result. Large increases in speed are not always successful because the required increase in speed of hand feeding cannot always be made.

Increasing the weight of the rim is also a satisfactory method. A spare flywheel may be bolted to the side of the one on the press, or carried on an extension of the shaft. One shop had some steel railroad tires about 3 ft. in diameter and occasionally attached these by means of bracket castings to gain more "punch" for odd jobs. When this is done care must be exercised to keep the wheel balanced.

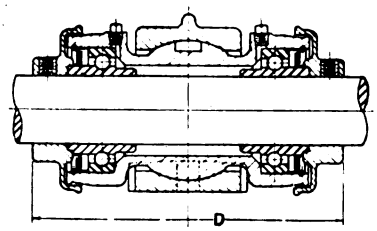
On punch presses and other similar machines with an adjustable stroke, it is a common expedient to increase the stroke for the purpose of decreasing the fraction T'/T which must be solved in the equation to determine the energy available. T' is the time in seconds of the actual cutting and T the time of the complete stroke. This works out well in some cases, but in one recently noted, it was tried to no avail. The men decided that the machine was too weak, when their reasoning was upset by the suggestion of the operator that they *shorten* the stroke and thus increase the ratio of the power arm to the work arm. It worked.

A plant that was cutting small shapes of leather from piles of soft hides an inch thick with cutting dies, resorted to a still different method of getting more power. The punch press had two notches in the flywheel hub to engage the bolt. The operator was a fast worker and could have "caught" every other stroke if the press had been running continuously, but continuous running would not have allowed time for shifting the work. He tripped so rapidly that the flywheel did not have time to recover its speed and, therefore, the machine often stuck. The remedy was to plug one of the notches in the hub. Then, with a white paint mark on the inside of the rim to indicate the position of the remaining notch, the operator could get the recovery of practically one whole revolution. His hourly output was increased above what it had been when the machine stuck from quick tripping.

An interesting "stunt" was done with a machine which had a "loaded" flywheel to increase its power to punch out pasteboard discs or wads. The legs were taken off and the press turned bottom side up; the legs were then attached on the side. This gave an unobstructed surface on top on which were placed the mailing tubes into which the wads were forced as cut. This was simpler than putting the tubes below, for then some sort of a follower would have been required in each tube to prevent crossed wads.

Dust Seal for Hanger Box and Pillow Blocks

UNDER conditions where there is an unusually large amount of dust, such as exist in cement mills, grinding rooms, mines or woodworking plants, it is almost impossible to exclude dirt from bearings. However, some industrial plants of this type are using a dust seal, as shown in the accompanying illustration, which can, if desired, be furnished with hanger boxes and single or double pillow blocks.



This shows the details of the dust seal on a hanger bearing.

The illustration, which shows the design of this seal, is practically self-explanatory. The extra seal is merely an extension on the self-locking collar which encloses the end of the box and fits over the corners so as to keep the dust from working down. The corners of the box are cut down and have a rim so that the seal closes down around them snugly. This rim stops any dirt that might otherwise get around. Since this seal revolves with the collar and shaft, it tends to throw the dirt out by centrifugal force and thus makes a dust-proof enclosure. This seal (Fafnir Bearing Company, New Britain, Conn.), is necessary only under exceptionally dirty conditions, since in most cases the pressed-steel dust caps are found sufficient.

Suggestions Which Reduce Cost When Ordering Bevel Gears

ANY article which is special or made to particular order must necessarily cost more than if standard products are used. This is especially true in many products used by industrial men. Frequently even special articles such as bevel gears have certain standard dimensions which most manufacturers of this equipment can supply.

Two of the most important items in the cost of small quantities of bevel gears are pattern and drafting-room expenses, together with the cost of entering the shop order with the necessary information for its proper execution. Each pair of gears requires a sketch or drawing showing outside diameters, face angles, edge angles, back angles, cutting angles, hub length and backing of each gear and pinion. Patterns also must usually be made unless standard listed gears are used.

Even if a manufacturer has several thousand well-assorted, bevel-gear blank patterns, it would be safe to say that in not more than one instance out of ten could existing equipment be used without alteration.

This may be better understood when we analyze the pattern situation more closely. Bevel gears mesh correctly in pairs only. Consider for example a 16-tooth pinion mating with a 48-tooth gear with ratio of 3 to 1. If the number of teeth in the pinion are increased or decreased, it will change the angles of the mating gear. As a matter of actual practice, if a pattern were made for the above pair of gears, it would probably be usable for the same number of teeth (48) of the same pitch and face to mesh with a pinion having one or possibly two teeth more or less than 16. However, a very careful check of the pattern would have to be made to determine this. From this it will be noted that to carry the necessary patterns for all combinations of bevel gears would be impossible.

By selecting listed bevel gears practically all of this expense is eliminated. Patterns are made and are used frequently. Also, complete drawings are kept on file. The saving of time as well as expense in executing an order is still further increased. Although it may sometimes appear difficult to use standard sizes of bevel gears where a definite reduction must be made, most installations, however, can be made to use standard sizes and ratios. For example, in most installations, bevel gears form only part of the reduction in speed. In fact, it might even be said that they are usually the second or third reduction, the first frequently being made by means of pulleys or spur gears, both of which can be readily manufactured in any reasonable ratio.

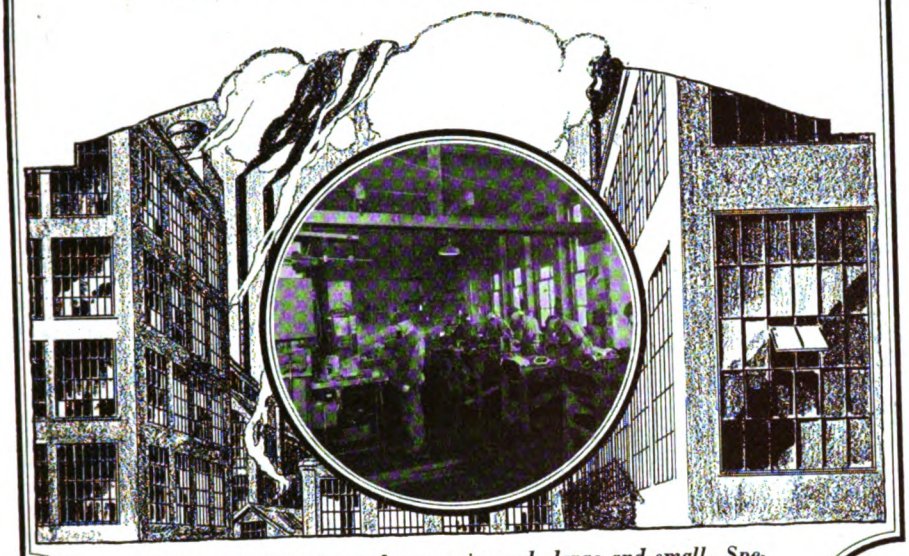
For example: If a total reduction of 12½ to 1 must be had involving a bevel-gear drive, it will be found advisable to commence with a standard listed pair of bevel gears, say 2½ or 3 to 1 for the second reduction, and make the first reduction by means of spur gears or pulleys of the proper size to complete the total reduction ratio desired.

It is usually much more economical to use rather small ratios of bevel gears, making most of the reduction where possible by spur gears. Bevel gears are much more expensive than spur gears, even if standard listed sizes are used. A bevel gear is not only more expensive than a spur gear when the pitch diameter, face and pitch are equal, but also the bevel gear will only transmit about three-quarters of the horsepower of a corresponding size of spur gear. This increases the cost per horsepower still more and makes the cost of bevel gears approximately twice that of spur gears on a cost-per-horsepower basis.

WARREN G. JONES.
President and Gen. Mgr.,
W. A. Jones Foundry & Mach. Co.,
Chicago, Ill.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Loose Rotor Bars Cause Trouble With Electric Grinder

RECENTLY, a ¾-hp., 3,600-r.p.m. electric grinder which would not come up to speed was sent in for repairs. I checked up both windings and the switch, but could not locate the trouble. I then tried cutting out the starting switch and bringing the starting leads to the outside of the motor, thinking that perhaps the switch springs were too weak, but still the motor would not come up to speed. The rotor appeared to be in good condition but after resoldering the bars the motor came up to speed and has worked satisfactorily ever since. In this instance, the rotor bars seemed to be so sound and tight that resoldering was used as a last resort.

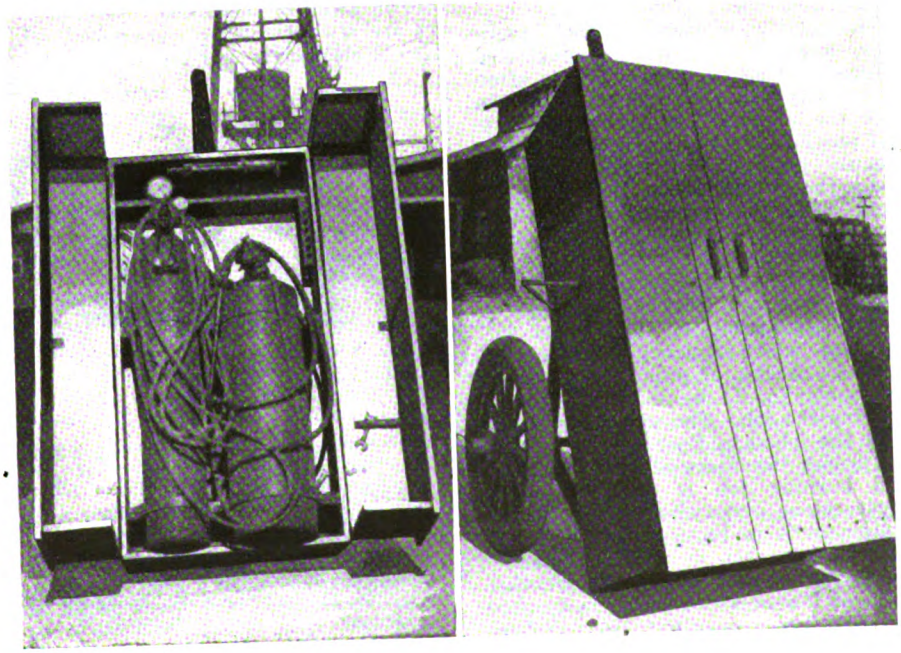
B. BELCHER.

Albany, Ga.

Trailer for Making Welding Outfit Portable

EVERY industrial man knows how much the usefulness of repair equipment is increased by making it portable. Frequently, this is easily done. For example, with oxyacetylene welding outfits, most manufacturers will provide a special two-wheeled warehouse type of truck for transporting the containers of the oxygen and acetylene. However, when it is desirable to extend the field of operation some distance, such an outfit is too small for convenient yard work.

In one plant where it was desired to use a welding outfit over a considerable area, a special all-weather trailer was constructed as shown in the accompanying two illustrations, which were furnished through the courtesy of The Linde Air Products Co., New York City. This trailer, in addition, carries all the auxiliary tools or accessories required, including a considerable quantity of welding rods. The weight of the containers is so placed that the trailer practically stands on end in the proper position for welding when the tongue of the trailer is released. However, it may be easily coupled on to a truck for hauling some distance, or if the distance be short, one or two men can easily move it. When the doors are closed and the trailer is standing on end as shown in the illustration at the right, it can be left out in almost any weather.



With a trailer of this sort, the range of the welding outfit is increased to the distance which a truck can take it. Also, there is sufficient space for every accessory needed.

Savings Affected by Dipping and Baking Armatures

IN A discussion given before a recent meeting of the Association of Iron and Steel Electrical Engineers, M. R. Armstrong, of the Westinghouse Electric and Manufacturing Company, made the statement that dipping and baking armatures have returned handsome dividends in the form of decreased motor maintenance. The following interesting data were given in corroboration of this statement:

A large electric railway company on the Pacific Coast installed an electrically-heated baking oven. At the same time a systematic schedule of dipping and baking armatures and field coils was inaugurated. Of the 1,800 motors in use, 70 per cent have been in service approximately 25 years. Before dipping and baking was inaugurated, failures were running at the rate of about 70 per month. Two years later, after the majority of the motors had been dipped and baked, failures were reduced to about 24 per month. This was a reduction in failures of approximately 64 per cent. The superintendent of this shop estimated that the total cost of dipping and baking, including all labor in removing and replacing the armatures, was between $6 and $7 per motor. He felt this expense was amply justified, as the life of the armatures was extended at least five years and the interruptions of service due to armature failures were very greatly lessened.

A large New England company operating in several towns adopted systematic dipping and baking. In one shop servicing 475 railway motors, the monthly failures were reduced from 150 to 28. In another shop servicing 400 motors, the failures were reduced from 100 to 24.

Another company has made available the following data from records kept over a period of 13 years: Early in this 13-year period, systematic baking of their railway motors was inaugurated. Before dipping was start-

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ed, the average service of a motor per failure was two years; after dipping and baking they obtained seven years' service per failure. Looking at this from a financial point of view and using their actual figures on cost and failures on the 300 motors involved, the figures show that their savings each year after paying all expenses of dipping and baking, amounted to $2,350.

All of the above examples are from railway service, but it is reasonable to assume that any method which will give such results under the conditions of railway service, will be correspondingly beneficial in industrial work.

Some of the Points to Think About When Repairing Storage Batteries

IN RENEWING storage batteries of stationary types, there are several details that must be given attention to prevent accidents which may be expensive, result in personal injury, or cause an interruption of service that may involve many dollars loss.

A careful check-up of the output of the battery which is to be renovated or repaired should be made before starting the job. Other questions that come up are: Can the battery in use be temporarily substituted? If so, are charging facilities available for charging the substitute battery that is to replace the original battery while undergoing repairs, changes, etc.? Is ample space provided for the temporary installation of the substitute battery? Are temporary battery leads accessible for use during the renovation? Can the substitute battery be operated by local attendants without involving any extraordinary precautions or complicated arrangements should an emergency arise regarding the charging and discharging of the temporary battery? All of these questions and possibly others that are involved in the changes or the kind of work that is to be done to the original battery should be given careful consideration to accomplish an efficient, careful and uneventful job.

The question of material, tools, facilities, and labor is usually neglected before starting the job and very often proves expensive in doing the job, in that the employer, contractor, jobber and possibly the workman suffer losses because preliminary details were not given the consideration that was due them. This not only applies to a battery job but to many other jobs where an interruption of service, or a delay is costly during repairs or changes.

The question of material and tools is, in my estimation, of the utmost importance, when efficiency must be considered. A list of supplies, material, and tools should be made up before starting the job. The workman who is to do the job should personally see that the proper items are shipped, and if a lead burning job is to be done and oxyacetylene or oxygen and hydrogen equipment is to be used for the burning, the operator or workman should check the equipment to see whether high- or low-pressure gas is to be used and that the proper burning tools are shipped. It has happened very often that the proper type of gas was not shipped to the job and the burning tools that were shipped could not be used because the connections on the tanks were different from those on the burning tools. This is due to the fact that a careful check of all material and tools had not been made. It is a well-known fact that high-pressure gas will not work successfully with low-pressure burning tools, and vice versa.

The question of other material and tools is likewise of importance. There is an old saying which is occasionally heard and sounds something like this: "A good workman or mechanic needs but few tools to do a job." This is true to some extent but an addition should be made to the saying and I suggest this: "Good and many tools and of the proper kind help the good workman or mechanic to work efficiently." Of course, mechanics are doing jobs without proper tools but compare these jobs with those done by the mechanic who has the proper tools, and I am sure that you will find a remarkable difference justifying the extra expense of purchasing the proper tools. Material in some cases is just as important if not more so than tools; inferior or less expensive material might show a saving on the books or contract, but will it prove to be more economical in the long run?

Protective clothing is also essential when working with electrolyte. These items should consist of rubber boots, rubber aprons, rubber gloves, and goggles of some description that will protect the eyes when either burning lead or pouring acid. Serious injury to the eyes may occur when least expected, especially when burning lead, as air pockets form and when there is an air pocket an explosion may occur, and invariably the eyes are injured. When pouring acid, splashing sometimes occurs and the eyes are usually injured. Protective material usually pays for itself in little or no time.

Parts of old batteries should be salvaged or sold for junk, which helps to lower the cost of repairs made on the battery. Sediment should never be thrown away or discarded. Junk dealers are always ready to purchase both the old electrolyte and sediment. After completing the job all tools that have been used should be washed in a solution of bicarbonate of soda, dried and oiled. This protects them against corrosion caused by chemical action.

Instructions usually accompany new plates when shipped from the manufacturer, stating whether they are in a charged or uncharged condition or otherwise treated. This also applies to new separators. Automatic water fillers used for replacing evaporation in the pilot cell of the battery usually have instructions regarding their installation. For the initial charge, instructions are also furnished regarding the number of hours the battery is to be charged, how to ascertain when the battery is said to be fully charged, etc., and unless otherwise specified these instructions should be closely followed.

Dallas, Tex. F. J. H. KRAUSE.

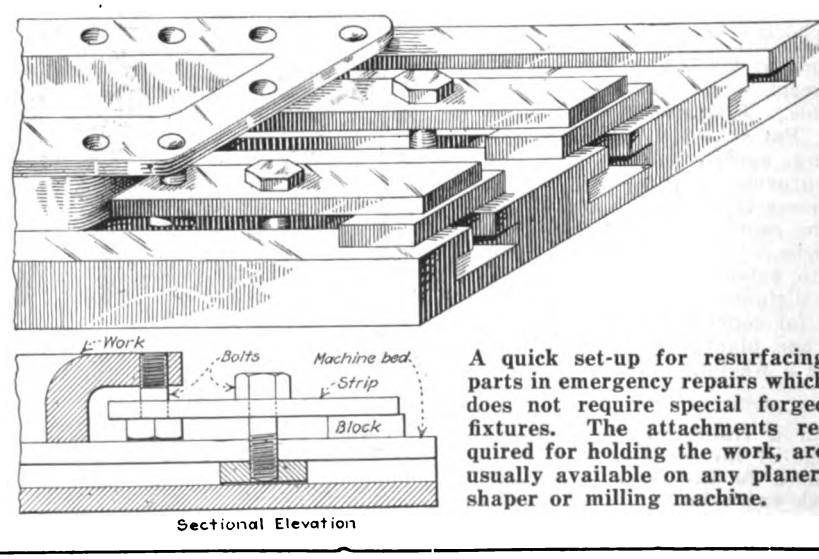
How to Make a Low Clamp for Refinishing Flat Surfaces

FREQUENTLY emergency repairs require resurfacing work on the shaper, planer or milling machine, which necessitates the use of some special form of clamp that will not protrude above the work. Many devices of this type are available to the machinist, but the repairman who is called upon in emergencies may not have them, as they generally consist of special forgings or machined parts.

The accompanying sketch shows a simple but serviceable holder, which can be made up of pieces available around almost any repair shop. This holder consists of a drilled strip, two bolts and a block for each of the clamps. These parts need not be of any particular shape or size and pieces on hand may be utilized.

In the majority of jobs the flanges are fitted with tapped holes. In some cases it may be possible to drill and tap holes. This fixture takes advantage of this condition as the work is held by screws in these tapped holes, as shown in the sketch. This simple clamp will save time and labor on any repair work to which it can be applied.

Washington, D. C. G. A. LUERS.



A quick set-up for resurfacing parts in emergency repairs which does not require special forged fixtures. The attachments required for holding the work, are usually available on any planer, shaper or milling machine.

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Some Emergency Alterations to Small Commutators

THE following examples of making alterations to small commutators to meet emergency conditions are actual experiences that have happened in the repair shop where I am employed. and as I know that they will give satisfactory results they may be of interest to other readers of INDUSTRIAL ENGINEER.

It must be always remembered, however, that in making such changes we are getting away from the original data and as we have to assume that the original design was the best for the machine in question, we must realize that in making any departure from the original we are taking a chance and the altered machine cannot be 100 per cent efficient, even if no noticeable difference in operation is detected.

Anyone who has had experience in repair shop work knows that there are many times when it is either impossible to get the necessary parts immediately, or if they could be obtained the expense would be such that the customer would not understand why a small repair job should cost so much. Knowing these things, it is common practice to make things do or fix them in such a way that they will operate to the satisfaction of the customer, who is usually interested only in the fact that the machine runs and gives him service.

We always feel that it is all right to make changes and "gyp up the job" if we can feel certain that the operation of the machine will not be impaired, but there is nothing to be gained by "just getting away with it" for the time being. Rather than have a dissatisfied customer from giving him a patched-up job that will not hold up, we either make it as good as new or advise him of the condition of the machine and the expense necessary to do the work properly and be guided by his answer. Sometimes the customers would rather take a chance. In case any reader finds it necessary to make some of the changes mentioned below, they should be as certain as possible that the change is feasible.

Some time ago, we had an armature with twelve slots and twelve commutator bars; the coils were wound with 150 turns of No. 29 d.s.c. wire, span 1-and-6. The commutator had a bar that was grounded solid. As it was a pressed, barreled commutator we were unable to open it and repair it, but as we had a thirteen-section commutator in stock, we put this on the shaft and jumped two bars together with a short jumper behind the shoulder. This made two bars the same as one and gave us the same number of bars as we had before, with the exception that one bar was wide. At the time we tried this, we were afraid that there would be sparking at the brushes, but when the motor was assembled and run the results were entirely satisfactory and there was no noticeable difference from the action we would have had with the proper commutator.

Another case of making what you have on hand answer for the part that you cannot get immediately was when we had a twelve-slot armature with a twenty-four-section commutator. The commutator was in such shape that it was impossible to repair it and we could not pick up another one like it; so we rewound the armature with twice the number of turns per coil and half the number of coils and put on a twelve-section commutator. The original data was twelve slots, two coils per slot, seventy-five turns of No. 30 d.s.c. wire per coil. We rewound the armature with twelve coils of 150 turns per coil. There was slight sparking at the brushes as the result of this change, but not more than occurs in many motors that are wound according to the original design.

Another time in putting all new mica segments in the commutator of a 1/6-hp. armature, a bar was lost. Losing one of the bars was pure carelessness and the proper thing to do would have been to make a new one, but the job had been promised for that afternoon; so we cut four more mica segments and put them in on the quarter and cut one coil out when we connected the leads in the commutator. In this case, also, there was no noticeable difference in the operation of the machine.

The same expedient could also be used in case a bar were so badly burned that it was beyond the point where it could be turned down to true it, or where an open circuit had caused bad burning between bars of the commutator.

In one instance, a customer had allowed an armature with an open circuit in the winding to run for a long time. The result was that a deep groove had been burned between bars, eating away almost all of the mica and almost half of each bar deep down into the commutator. In this case, there was so little of the bar left at the top that we filed both bars down to a size where together they made up the width of one good bar. We then assembled the commutator and put in a couple more mica segments to make up the width of the missing bar and cut out the coil that had the open circuit in it.

Trouble with short-circuited commutator bars caused by carbonized spots in the mica segment is very common and the best thing to do is to put in a new segment. However, when the commutator is one of the pressed or crimped type that has the barrel and end rings riveted or crimped over, it is nearly impossible to open it up for repairs because of the difficulty encountered in getting it tight again. A great many of the small commutators are of this crimped type and whenever they come in with shorted bars from carbonized spots, we try to pick out the carbonized mica with a sharpened hack-saw blade.

Quite frequently, there are several small bad spots; we clean these out and plug the holes with Early's commutator compound. litharge and glycerin, or finely powdered mica dust and waterglass. If the hole goes deep down between the bars and cannot be cleared, we plug it, jump the two bars together and cut out a coil there. This is really better than leaving some of the burned mica in and using the commutator in this condition. because in time these shorted bars will cause the coil to burn out, while with the bars jumped together and a coil cut out there will be no noticeable difference in the operation.

Darby, Pa. GEORGE WM. HANLON.

Handy Method of Obtaining Proper Brush Spacing

IT OFTEN happens that the man who is investigating a reported case of trouble, is not equipped with tools or instruments to correct it, mainly due to his being misinformed as to the nature of the trouble or the type of apparatus to be worked on. Take the case of a d. c. motor or generator which is commutating poorly. Invariably the proper thing to do first is to check the brush spacing if there is any possibility of the spacing being incorrect.

The most accurate method of doing this spacing, and the method commonly used, is to place a piece of paper around the commutator and after marking where it laps, remove the paper and step it off with dividers or measure with a scale or rule a number of spaces equal to the number of brush studs.

After the paper has been divided off in this way, the writer may add that lines should then be drawn across the width of the paper at right angles to the length to check each brush-holder or box and not one holder only on each stud, as the insulating washers may be warped. In this case steps must be taken to make all holders line up parallel to the commutator segments.

When dividers, a rule or square, are not available this method of spacing can still be used and if a little care is taken, an accurate job can be made as follows:

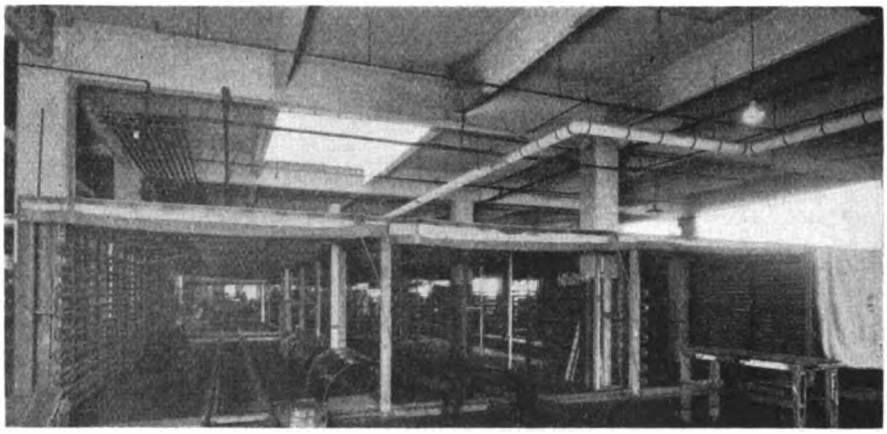
Take any piece of paper about 8 in. longer than is required to encircle the commutator and after marking it with a straight edge, cut off one side parallel to the length; then fold it back about 6 in. on the length, keeping the edges even and after creasing, cut the 6 in. off. A piece will now be had with two straight sides at right angles to each other and approximately 2 in. longer than the circumference of the commutator. If a straight-edge is not available a piece of newspaper will answer the purpose as this will have the two edges already cut at right angles to each other.

After placing this strip of paper on commutator with the straight side against the shoulder or risers, mark where it laps over. Then remove this strip of paper, fold it in half and crease carefully, keeping the edges even. A piece of paper will now be had which will give proper spacing for a 2-pole machine: namely, brushes 180 deg. apart. For a 4-pole machine or 90-deg. spacing, fold each 180-deg. piece in half and crease. A 60-deg. or 30-deg. spacing can be made in the same manner by folding the paper on the third or 120-deg. instead of on the half or 180 deg.

The above method will not only be found to be convenient, but it is both quick and accurate.

Repair Foreman, JOHN E. HOLTMAN.
Westinghouse Elec. & Mfg. Co.,
Denver, Colo.

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This is one of three kilns constructed of gypsum wallboard, which have been in service six years.

The ceiling and walls of this kiln in a truck factory near Buffalo, N. Y., are built up of sheets of non-combustible gypsum and fiber on 2-in. by 4-in. studs and cover a floor area of 40 ft. by 60 ft. Wallboard is nailed directly to the studding with cement-coated nails and the joints are filled with a special finisher. In some cases wooden panel strips are used, as on the kiln shown at the beginning of this article, but if care is exercised in making the joint it is hardly noticeable and does not need to be covered up. This material can be used in kilns operated up to 200 deg. F. and 35 per cent humidity.

Uses of Wallboard in Plants

(Continued from page 237)

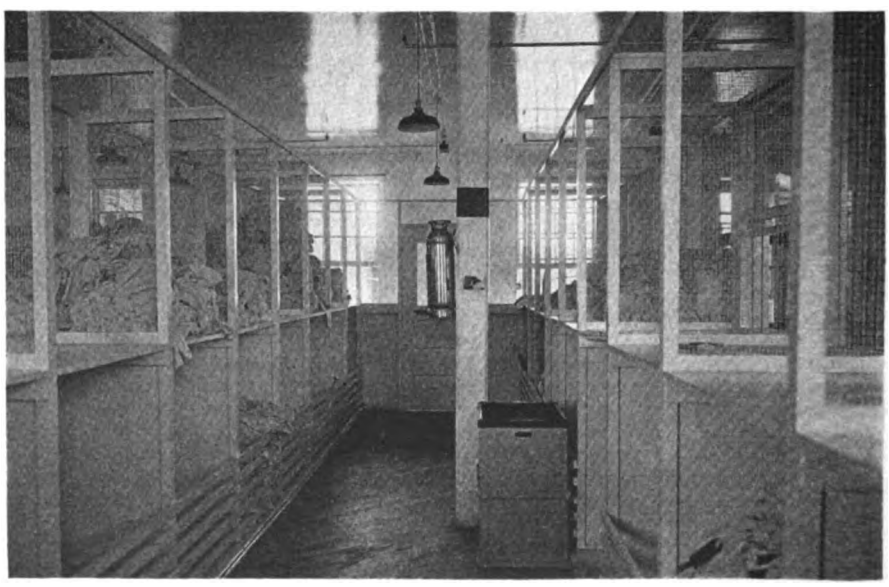
nailed directly to the studding and the joints filled with a special finisher. In some such kilns the joints have been covered with wooden panel-strips but this is not necessary. These kilns are operated at a temperature of 150 deg. F. to 170 deg. F. on a 24 hr. a day schedule with a low heat loss. In these kilns the wallboard is used on both inside and outside for double heat insulation.

Other than automobile plants also make good use of these kilns. For example, 11,000 sq. ft. of wallboard were used in the dry kiln of the Brook Candy Company, Chattanooga, Tenn., where it is under a constant temperature of 140 deg. F. This material is especially appropriate here, because it is absolutely non-odorous as well as free from crumbling. In some installations Sheetrock has been used in the construction of kilns in which a temperature up to 200 deg. F. is maintained, with 35 per cent humidity. This material is not recommended for use at a higher temperature or humidity.

Gypsum suffers little from gases that occur in many manufacturing processes. Any gases or fumes which affect the fiber covering or the fiber in the wallboard will affect it. Under most conditions ordinary paint will protect the fiber covering on the wallboard from the action of gases or fumes. There are special protective paints, that are not affected by acids or fumes. These may be used in cases of necessity.

Among other uses, which might be mentioned are: lining of lofts, fire protection for basement and other ceilings, as an insulator instead of wooden sheathing behind brick or masonry veneer or wooden siding, as a fire stop in partitions and floors and as a sound deadener between rough and finished floors.

In fireproof buildings it is also used for the construction, either on metal or wooden studs as supports, of walls, partitions and ceilings. Another common use is in the construction of fresh air ducts, ventilating shafts, enclosures for pipe lines, and so on. Its dual purpose as an insulating material, the fact that it does not warp and also the large sizes in which it can be obtained make it adaptable for mounting charts, maps, blueprints, shop bulletin boards, for the backs and bottoms of cases and drawers for filing blueprints and other light material and for many other applications which any ingenious plant man can easily find.



Wallboard was used in the construction of this storeroom.

Besides using gypsum wallboard to finish the walls and ceiling of this storeroom the same material was used in the construction of the sides of these stock bins. As this is a non-combustible material, the fire-resisting qualities are especially desirable in storeroom construction.

Winding Armatures by Machine

(Continued from page 234)

potential will be sure to break down the insulation of the unimpregnated part sooner or later.

The high dielectric strength of enameled wire helps greatly in preventing breakdowns. Wires which have enamel as one of their coverings are to be preferred, in small sizes, for this reason as well as for their heat-resisting qualities.

There are many good varnishes on the market, but owing to the fact that enamels are themselves applied to the wire as a liquid varnish, the insulating varnish used should be designed for use on enameled wire. Otherwise the varnish solvent may cut the enamel. For the same reason do not soak the armature too long in the varnish. It should be immersed just long enough for the varnish to penetrate the coils.

Do not use spirit or non-baking varnishes for impregnating. Shellac varnishes come under this head; their use for impregnating is practically discontinued.

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Overhauling Electrical Instruments

(Continued from page 222)

the friction compensation has been adjusted with the potential circuit connected to the service side. (6) In the case of induction meters, short-circuits in the current coils. Of course, we have to deal with only the first-named cause, as vibration, improper connections, short-circuits and so on would be eliminated by our previous work and by the conditions under which the meters are tested. We overcome any tendency to creep by proper adjustment of the compensating or shunt coil.

Testing of induction, or alternating-current, meters conforms closely to the procedure outlined for direct-current meters, except that a high-grade indicating wattmeter is used to measure the power passed through the meter.

With polyphase meters each phase is tested and corrected separately. Then the current coils are connected in series and the potential coils in multiple across the line for a final check of the meter. One of the accompanying illustrations, Fig. 4, on page 222, shows our test bench. As will be noted, there is mounted at the back of this bench two testing boards from which any desired voltage, frequency or number of phases can be obtained for testing any kind of indicating or recording instrument. Several motor-generator sets supply power to this board.

The headpiece at the beginning of this article shows a general view of a portion of the *Meter Department*, with the test bench in the background.

After a meter has been tested and properly adjusted the cover is fastened in place and the meter either returned to the customer or sent to stock.

Overhauling and testing of voltmeters, ammeters, power factor meters and so on is carried out in substantially the same manner as outlined for watt-hour meters. These instruments likewise come to us exhibiting all of the different kinds of damage that may be caused by abuse or carelessness in handling, neglect, accidents, and natural wear and tear. Thus, the coils may be burned out or short-circuited, the instrument may have been dropped, with consequent breakage of pivots or jewels or damage to other parts. Again, the torsion springs in voltmeters and ammeters seem to become brittle with age and eventually break, thus putting the instrument out of commission.

When such instruments are purchased or sent in for repair they are thoroughly cleaned, if necessary, and then carefully inspected to determine what repairs are needed. New coils or new springs are put in, as may be required, flattened pivots are ground and polished and any other needed repairs are made. If the cases are bent or badly scratched they are straightened and refinished. The instruments are then checked against our standards and after any necessary adjustments have been made they are assembled in their cases and either returned to the customer or sent to stock.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Ball Bearings—A booklet entitled, "The Super-Strom," is devoted to a discussion of the design, material, workmanship, load-carrying capacity and dimensions of the "Super-Strom" ball-bearing designed for heavy duty.—Strom Ball Bearing Mfg. Co., 4593 Palmer St., Chicago, Ill.

Insulation Lacquer—A broadside entitled, "Why Dolph's Is Different," describes Dolph's air-drying electric lacquer and black baking Chinalak for the protection of electric motor windings.—John C. Dolph, 168 Emmett St., Newark, N. J.

Portable Electric Hoist—Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill.—Bulletin 76-E describes and illustrates the Sullivan electric portable hoist made in single-drum and double-drum types, which is capable of lifting a vertical load of 2,000 lb. at the rate of 107 ft. per min.

Materials-Handling Equipment — Revolvator Company, 336-352 Grand Ave., Jersey City, N. J.—Bulletin 71 describes the Revolvator hand-operated lift-truck. Bulletin 75 describes the motor-driven, portable elevator. Bulletin 72 describes the line of barrel racks for use in connection with a portable elevator.

Oil Circuit Breakers—General Electric Co., Schenectady, N. Y.—Bulletin 47495.1, of 32 pages, is well illustrated by photographs, tables and diagrams and contains other details covering the construction, operation, price and characteristics of four new types of oil circuit breakers for controlling and protecting circuits of large capacity.

Ratchet Diestock—The Borden Co., Warren, Ohio—A folder describes the No. 3 Beaver Jr. ratchet diestock for threading 1-in. pipe and all smaller sizes in corners or other close places.

Stationary Dead-Front Switchboards—General Electric Co., Schenectady, N. Y.—Bulletin 67111-Class 15, describes this equipment with brush contact lever switches for 125 and 250 volts alternating or direct current and 500 volts alternating current from 30 to 600 amp.

Automatic Remote Control Starter—Bulletin 219 describes and shows diagrams of the construction and operation of a new automatic remote control starter for alternating current, squirrel-cage motors. These are made in two- and three-phase designs for 25, 40, 50 and 60 cycle at 220, 440 and 550 volts.—Crocker-Wheeler Co., Ampere, N. J.

Industrial Roller Bearings—American Roller Bearing Co., Pittsburgh, Pa.—Catalog 1006 carries a number of installation sketches, load capacity tables and photographs of roller-bearing-equipped machinery in a wide line of industries. These are essentially industrial bearings and are made in standard and heavy-duty types. Applications vary from heavy-duty presses to open-hearth charging cars.

Theft-Proof Lamp Sockets—A folder describes the construction and method of applying the Ren-lock to brass, porcelain or weather-proof sockets. With this lock it is impossible to remove the lamp without breaking the bulb, for which a special bag is provided.—Ren Manufacturing Co., 550 Main St., Winchester, Mass.

Portable Spray Painting Equipment—The DeVilbiss Mfg. Co., Toledo, Ohio—A circular describes the DeVilbiss portable spray painting system for spray painting houses, factories, building interiors and exteriors, railway equipment, bridges, ships and all kinds of large or stationary work. This includes a description of the various types of outfits and other equipment, together with their operation.

Switch Houses—Condit Electrical Mfg. Co., South Boston, Mass.—Bulletin 458 describes switch houses for indoor and outdoor service to afford protection for switching equipment where the power used does not justify the erection of a more expensive substation.

Portable Woodworking Machines—J. D. Wallace & Co., 134 South California Ave., Chicago, Ill.—A broadside consists of a number of illustrations showing some of the wide applica-

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tions of Wallace portable machines in woodworking plants. These machines consist of portable jointers, planers, lathes, band saws, plain and universal saws, solder and glue pots. These machines are taken to the job or given to individual workmen to use at their bench or for maintenance work.

Interlock on Switches—Chas. Cory & Sons, Inc., 183-7 Varick St., New York City—Bulletin 105-29-B is on the new Cory-Robinson Interlock, which is designed to prevent accidental opening of disconnecting switches while under load by station personnel and to prevent damage from the same cause through malicious tampering.

Electrically Driven Tools—James Clark, Jr., Electric Co., Louisville, Ky.—Catalog 29 describes the Clark line of electrically-driven portable drills and their various attachments, center grinders for lathe heads, toolmaker's grinders, hand, bench and pedestal grinders and buffers, as well as other tools.

Electric Fans—Wagner Electric Corp., St. Louis, Mo.—Bulletin 143 entitled, "Wagner Fans," describes the various types of oscillating and non-oscillating desk, wall and ceiling fans for alternating and direct current, manufactured by this company.

Portable Electric Tools and Shop Equipment—The Black & Decker Mfg. Co., Towson, Md.—Catalog 8, under the above title, is a complete catalog, illustrated, of the portable electric drills, grinders, valve grinders, screwdrivers, socket wrenches, post and bench drill stands, and electric bench and pedestal grinders manufactured by this company.

Circuit Breakers—Roller-Smith Co., 229 Broadway, New York City—Bulletin 530 describes in 24 pages the technical details of the construction and operation and lists the various standard types of this equipment for use on direct and alternating current circuits of 6,600 volts.

Permeater and Core Loss Apparatus—Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.—Bulletin 533 describes the "Burrows Permeater" for testing bar samples of steel for normal induction, residual induction and coercive force data, and also the "Epstein Core Loss Apparatus" which is used to test electric sheet steel for determining probable core loss through hysteresis and eddy currents.

Hand Elevating-Platform Truck—Sturdi-Truck Mfg. Co., Inc., 511 Orange St., Wilmington, Del.—A folder describes the Sturdi-Truck material handling service. Circulars show the construction and operation of this hand-lift truck, which has a step-by-step lift of 3 or 5 in., according to the model.

Steel Belt Fasteners—The Bristol Co., Waterbury, Conn.—A folder illustrates the application of the Bristol steel belt lacing and belt fastener for making belt repairs in industrial plants. This lacing is of the staggered staple type, and is applied with a hammer.

Pressure Type Water Filters—Graver Corp., East Chicago, Ind.—Bulletin 501, with the above title, describes filtration methods and shows the construction of the Graver filters which are furnished with a perforated strainer plate, instead of a pipe manifold and strainer head for the collection of filtered water.

Pressed-Steel Truck Platforms—The Youngstown Pressed Steel Co., Warren, Ohio—An 8-page catalog describes and illustrates the Youngstown corrugated, pressed-steel platform for hand- and power-elevating trucks, as well as the solid and sectional boxes, stake platforms and other equipment which are made to be used in connection with the platforms. Pressed-steel tote pans and compound boxes are also described.

Electric Equipment for Cranes—General Electric Co., Schenectady, N. Y.—Bulletin 48732 entitled, "Electric Equipment for Cranes," is an attractive 35-page bulletin well illustrated with photographs, diagrams, tables and charts. This bulletin has particular reference to crane motors and control, brakes, limit switches and other crane protective and operative features.

Direct Fired Unit Heater—American Blower Co., Detroit, Mich.—A folder describes the American Blower direct-fired unit heater for use in industrial plants.

Hammers With Renewable Head—The Bilton Machine Tool Co., Bridgeport, Conn.—A folder describes the New-Tip hammer which consists of a head in which new tips may be inserted by simply removing a screw and retightening it. Tips are supplied in lead, copper, fiber, or rubber in five sizes, weighing from ½ lb. to 6 lb.

Electric Fans—The Robbins & Myers Co., Springfield, Ohio—Catalog 1243 describes the R & M electric fans for alternating or direct current circuits in oscillating, non-oscillating, ceiling and ventilating fan types.

Materials-Handling Equipment — Barrett-Cravens Co., 1328 West Monroe St., Chicago, Ill.—A group of small bulletins describes the various types of hand-lift trucks and other materials-handling equipment manufactured by this company.

Adjustable Lamp Supports—Columbia Electric Co., 1109 Pine St., St. Louis, Mo.—A circular describes the universal bracket which is designed to give an extensionable and adjustable arm for lamps and reflectors. These brackets are designed to fit a variety of machines in industrial plants.

Material-Handling Equipment for Foundries—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.—Bulletin 61 describes the Shepard Electric Cupola Charger, and other electric hoisting and load moving equipment for foundries. The cupola charger is made in three sizes of 4,000, 6,000 and 10,000 lb. capacity in either the floor-operated or cage-operated types.

Automatic Time Switches—Albert and J. M. Anderson Mfg. Co., 289-305 A St., Boston, Mass.—Bulletin 37 describes the Anderson equipment for controlling electric circuits in which the element of time enters as the important factor such as on electric signs, automatic substations, time switches for two-meter service, switches for turning on and off night lights, battery charging, motor control and other purposes.

Ball-Bearing Motors, Buffers and Grinders—U. S. Electrical Mfg. Co., 200 E. Slauson Ave., Los Angeles, Calif.—A folder describes the U. S. electric grinders, buffers and polishers, as well as horizontal and vertical motors, all of which are provided with ball bearings.

Single Conductor Potheads—Price list 50 covers the complete line of single-conductor potheads with cap nut terminals mounted directly on the porcelain tube.—G. & W. Electric Specialty Co., Inc., 7440-52 S. Chicago Ave., Chicago, Ill.

Electric Fans—Century Electric Co., 1827 Pine St., St. Louis, Mo.—Bulletin 37 describes the Century alternating and direct current, oscillating and non-oscillating portable and ceiling fans.

Details of a Fuse Color Scheme

(Continued from page 229)

yellow, paint two red rings around them, and put sufficient fuse links in parallel to give us 150-amp. rating. The yellow case would indicate a 45-amp. fuse; one red ring around it would indicate a 100-amp. fuse, and the two rings would bring it up to 150 amp. Thus it can be seen that the red *rings* indicate variations in size above the rating for that color, just as the red *stripes* indicate variations in size below the rating for that color, as given in the accompanying table.

The practice of overloading a fuse cartridge is not to be recommended, however, and should be done only in case of an emergency, for temporary use.

Sometimes, also, it is desirable to put in solid fuses, as in the case of the neutral of a 220-110-volt lighting circuit and in this case we paint the whole cartridge red.

In case a maintenance man goes out on a call with fuses of the wrong rating, but the right size cartridges, he wraps a piece of tape around each cartridge to indicate emergency use, and replaces them with the proper fuses as soon as possible.

I installed this system in the plant of the Peerless Motor Car Co. at Cleveland, Ohio, and am at present installing the system in the entire plant of the Willard Storage Battery Company.

In both plants, the system is proving that our diagnosis of our troubles and the remedy decided upon were correct, and very satisfactory results are being obtained from the use of this method of marking and handling fuses.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

June, 1925

McGraw-Hill Co., Inc. Chicago, Ill.

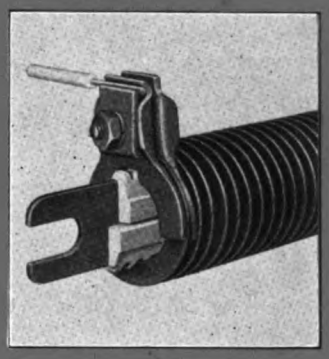
Cool joints do not fail



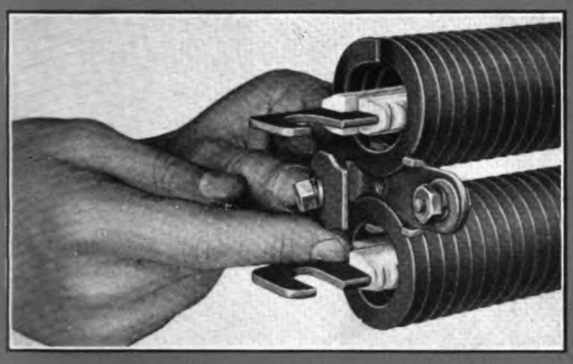
Method of making terminal connections on Monitor Edgewound Resistors.



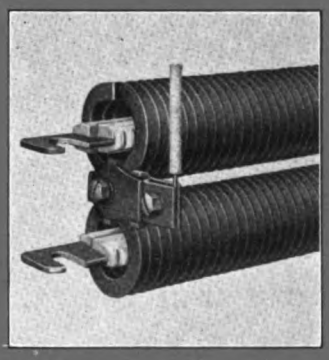
This method of attaching wires insures a good, mechanically strong connection.



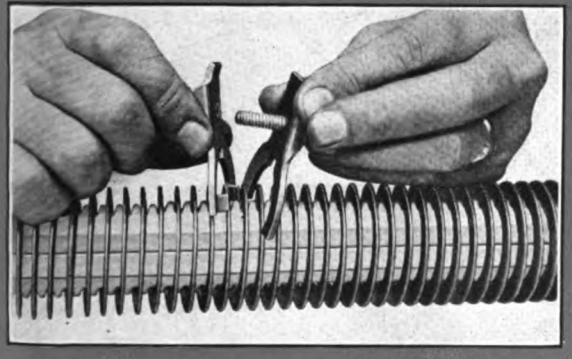
Terminal connection in place. The clamp terminal is rigid and will not work loose



Method of joining adjacent Monitor Edgewound Resistor Units together electrically.



Bridging clamp in place. Note the terminal used for taking off tap.



Method of taking off tap on Monitor Edgewound Resistor. Tap can be placed at any point. Same type of clamp used as for terminals.



Tapped resistor unit. Clamp takes firm, rigid grip on ribbon and cannot work loose.



Monitor Edgewound Resistor assembled

JOINTS are weak points in the ordinary resistor. Poor joints mean excessive resistance, undue heating and possible burnouts. Cast-iron grid resistors have about fifty joints in series in each section.

There are no series joints in Monitor Edgewound Resistors except where one unit is joined to the next. Taps and terminals are made with powerful clamps which contact completely with the ribbon.

This is only one of the many superior features of Monitor Edgewound Resistors fully described in Bulletin 107.

Monitor Controller Company

BALTIMORE, MD.

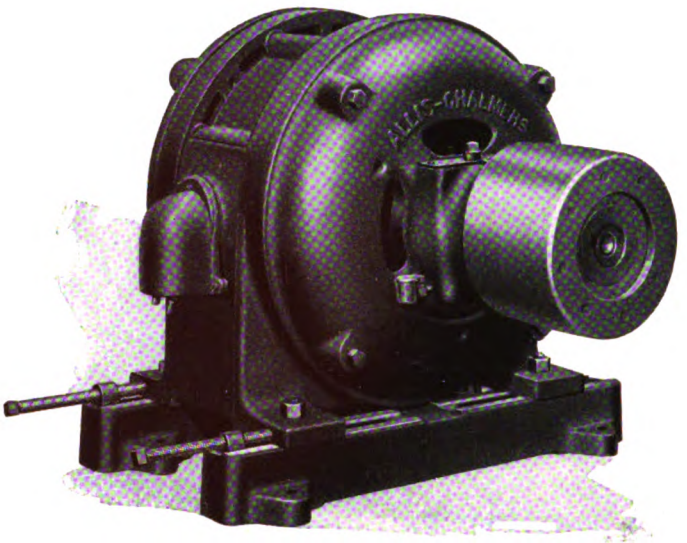
The Original "Just Press a Button" System

Boston	Cincinnati	Buffalo
New Orleans	Pittsburgh	New York
Birmingham	Chicago	Cleveland
Detroit	Philadelphia	St. Louis

Monitor Edgewound Resistors

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Type "AR" Motors have an All Steel Frame

Unusual rigidity is imparted to the new type "AR" Induction Motor, due to its all-steel frame construction. The stator end frames and feet are integral and are made from electric steel castings. They do not break. The use of cast steel for many parts ordinarily made of cast iron distinguishes the "AR" motor from the usual run of contemporary types.

Built in capacities ranging from ¾ to 200 Horse Power

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Electrical Machinery
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MILWAUKEE, WISCONSIN. U.S.A.

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Steam and Electric Hoists
Air Compressors - Air Brakes
Agricultural Machinery
Condensers

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Volume 83 Number 6

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
JAMES H. McGRAW, *President*
JAMES H. McGRAW, JR., *Vice-Pres.-Treas.*

Chicago, June, 1925

G. A. VAN BRUNT, *Managing Editor*

Just a Word on the Side

About My New Boss and Your Job and Mine



FELLOWS, I want to let you in on a little secret before official word may come to you from some other source. I've got a new boss whom I have worked with so long that he is new only in an official sense. It's G. A. Van Brunt, who has been Managing Editor of INDUSTRIAL ENGINEER and has worked hand-in-glove with my old boss since the paper was started. Van does not know that I am writing this and so I can speak freely and sneak this page into this issue while he's not looking. He's such a modest cuss and such a fine fellow and knows his stuff so well that I want you to get to know him just as well as I do. He has worked with my old boss long enough to get the benefit of his 15 years of experience in editing engineering publications and with that as a background, we are going to continue to give you just the best paper we know how to make with your co-operation. As my old boss has often said, "INDUSTRIAL ENGINEER is your paper and you can make it fit your own needs if you will continue to give us from time to time the benefit of your suggestions for articles that you would like to have us publish, and offer comments on changes or improvements that will help you in your work."

As to my old boss, D. H. Braymer, he has not left us completely but has simply transferred himself to a related line of work. We will still have his affection and a part of his time in an advisory capacity, and I feel sure that from now on you will see his name in the paper frequently in connection with discussions that he knows best how to write on the new work he will do. In brief, as I understand his plans, he will organize an engineering staff of specialists who will devote their time to the installation of power applications in industrial plants, buildings and power plants in the states of Iowa, Nebraska and the cities of St. Joseph and Kansas City. His office and headquarters will be in Omaha, Neb., and if you want to write him from now on simply address your letters to 727 Woodmen of the World Building, Omaha, Neb.

He takes with him our best wishes and I am sure he will have yours, too. On his part, he has authorized me to say that the time he has spent in working with you on your problems has created an affectionate regard for you as men and as doers of things worth while. I know that his feeling in this connection is genuine, for I have frequently heard him say that INDUSTRIAL ENGINEER readers have just the kind of brains and hands with which he likes to work. A better tribute none of us who are practical men could ask from another who has been one of us in spirit and action for a period of 15 years.

Practical Pete

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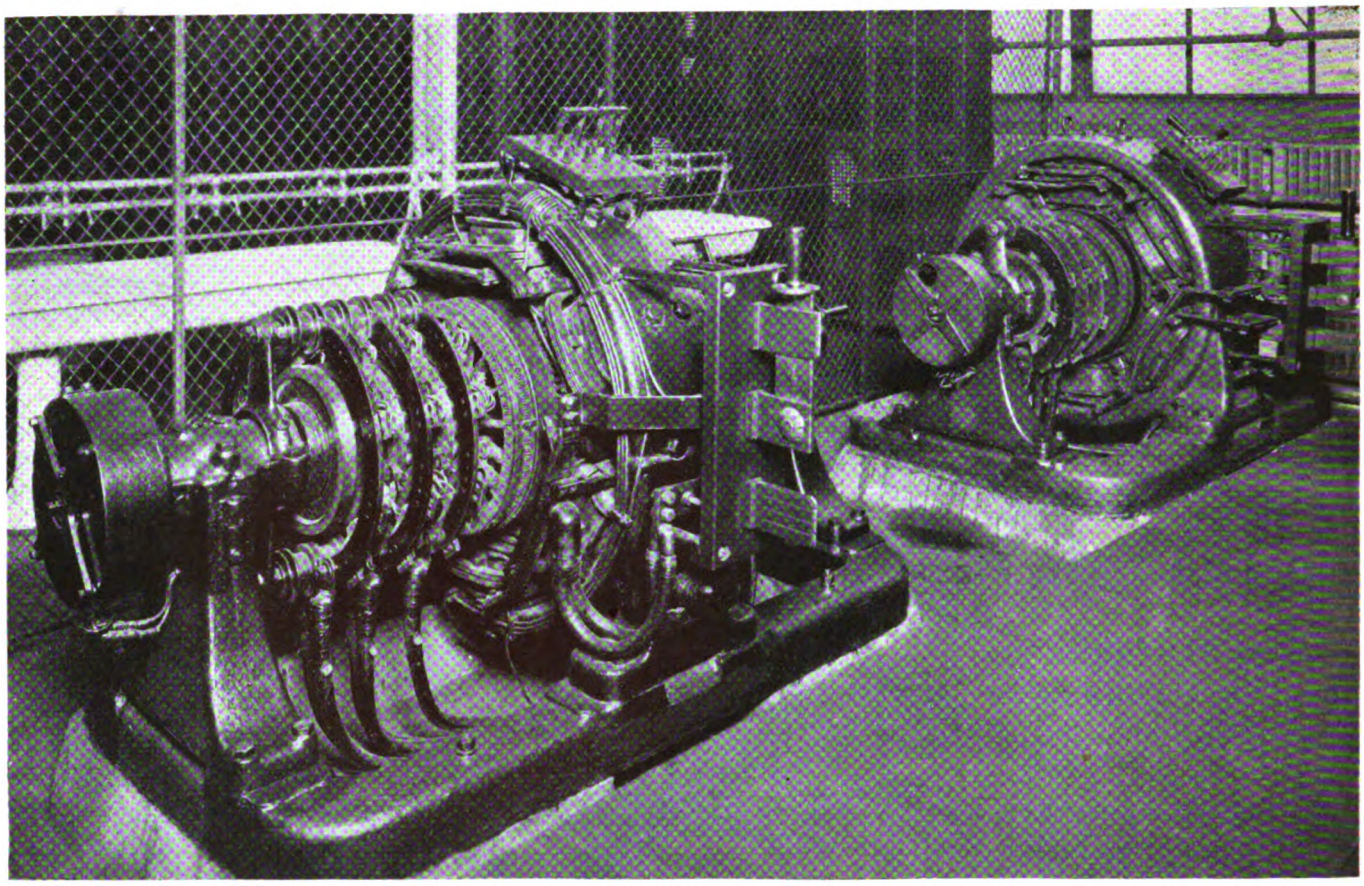


Fig. 1—The rotary converter shown at the left is a spare and is normally operated only in case the other one fails.

By floating it on the line as a synchronous condenser with over-excited shunt field, as is described in this article, a surprising amount of power factor correction was obtained. During periods of very light load, considerable corrective leading current was obtained from the other rotary. The machines are rated at 200 kw. and run at 1,200 r.p.m.

How Power Factor Was Improved by

Using Rotary Converter as Synchronous Condenser

Or as a Rotary Operating at Low Power Factor and Carrying a Small Load, Together With Graphs Showing the Amount of Corrective Current That May Be Obtained by Either Method

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

SOMETIMES rotary converters must be operated for considerable periods at loads far below rating. In industrial plants these light-load conditions are frequently coincident with correspondingly light loads on the other electrical power equipment. If there is much induction motor load, such a light-load condition means a low average power factor of the total load. Under such conditions any corrective leading current which may be furnished by the under-loaded rotary or rotaries will be very welcome.

I was lately confronted with the following problem: For a special purpose of great importance in an industrial plant, a rotary converter had been installed. To assure the necessary reliability of service, a second converter had been installed for use in case of breakdown. Of course, this second machine was very seldom required. Under certain circumstances, the load on the converter in service was very light for days at a time. Leading current for power factor correction of induction motor load would be most useful. Just how much leading current could safely be taken from the lightly-loaded converter? Could the spare converter, operated as an over-excited synchronous motor without direct-current load, deliver a leading corrective current in worth-while quantity, without abnormal heating of the tap coils? If so, how much?

It is a well-known fact, that the heating of the individual coils in a rotary converter armature is unequal. The tap coils operate under the most unfavorable conditions and run the hottest. The relative heating of all coils varies with the power factor at which the converter is operated. Under all power factor conditions, however, the tap coils are hotter than any others and with the same kilowatt load on the converter the lower the power factor, the hotter are the tap coils.

Various discussions of this matter have been published from time

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to time. One of the clearest and most useful of these discussions was contributed by Nicholas Stahl to the *Electric Journal* in 1912. Mr. Stahl published a set of curves similar to those in Fig. 2. These curves show that the kilowatt load which can be carried on a given rotary converter decreases very rapidly indeed with comparatively small departures from unity power factor. When a converter must carry continuous kilowatt loads approaching continuous rating, or short-time kilowatt loads approaching the corresponding short-time rating, it is evident that there is no safe alternative but to operate quite close to unity power factor.

Unfortunately the performance of rotary converters with very light load under very low leading power factor conditions was not included in Mr. Stahl's article nor in any published discussion of the subject that was available at the time. Since the work on which this article is based was completed, an article on this subject has been published by C. W. Bates in *Electrical World.*

Inasmuch as I was unable to find the answers to the questions raised in preceding paragraphs of this article, I decided to investigate the subject myself. The first step was to compute the curves shown in Fig. 3. These curves are similar to the curves shown in Fig. 2 except that they are carried to lower power factors. The agreement between my curves and the previous curves is very close at high power factors. The discrepancy of about 5 per cent at lower power factors is probably due to the fact that Mr. Stahl's curves are based on a converter having three or four armature coils per pair of poles, while my curves are based on a rotary having very many coils per pair of poles. This assumption was made because it greatly simplified the computations without introducing any considerable error. The discrepancy is small and my curves err on the side of safety.

Effect of Leading Power Factor Current at Light Loads

At first glance, Fig. 3 would seem to indicate that it is unsafe to operate even a lightly-loaded rotary at any appreciable load. Second thought suggests, however, that the small kilowatt loads allowable at low power factors represent considerable a.c. ampere loads. That is, even at very low power factors a fairly heavy wattless corrective current is allowable without causing tap coil heating above normal. It is evident that under the conditions outlined above, the point of controlling interest is the *a.c. ampere load* that can be carried, and not the kilowatt load. To bring out clearly the possibilities in this respect, the curves shown in Fig. 4 were plotted. These bring the matter out in its true light. Evidently a rotary will carry safely a surprisingly large wattless corrective current if the kilowatt load is low at all times.

THAT A ROTARY converter should be operated at very close to unity power factor is certainly true at full load. Mr. Drake, shows, however, that at light load a comparatively large amount of leading wattless corrective current can be taken from standard rotaries without exceeding their normal temperature rating. In this article he presents curves which show just what percentage of rated kilowatts and what percentage of rated alternating-current amperes any two, three, or six-phase rotary converter will carry at any power factor from unity to zero without exceeding normal continuous heating guarantees as to tap coil or armature heating. This factor varies to only a very slight extent with design and these curves are universal in application.

Where a duplicate or spare rotary is installed to assure continuity of operation, it is very seldom operated. In systems where wattless corrective current is desired to improve the power factor, such a machine may often be operated to excellent advantage as a synchronous condenser and may, without exceeding normal heating, be operated at an astonishingly high percentage of rated alternating-current ampere capacity. In this article Mr. Drake gives the details of operating a rotary in this manner.

When it is possible to operate a spare rotary for power factor correction purposes alone, without taking any direct-current load out of it at all, the machine is really a synchronous motor, not a rotary. The heating of the armature coils is no longer unequal, for the inequality of heating is a result of the "mixture" of alternating current and direct current in the winding of the rotary. With no direct-current load there is no direct current to "mix."

Under these circumstances the tap coils are no hotter than any others, and conditions would appear to be much more favorable for a heavy leading corrective current. A thorn lies in the following fact:

Under ordinary operating conditions the heating of rotary converter armature coils is so unequal that the controlling feature in design is not the *average heating,* but the heating of the hottest coils, the tap coils. With very light loads at low power factors, this inequality of heating becomes less and less. The relative heating of the tap coils decreases but the heating of the coils between taps becomes relatively greater. Finally we reach a point where the tap coil heating is no longer the controlling feature; the average heating of the whole armature is the controlling feature. This average heating is represented by the left-hand dotted part of the curves in Fig. 4. These curves enable an operating engineer to set a limit to the alternating-current amperes which can safely be allowed on any converter at low power factors, as limited by armature heating.

Shunt Fields May Limit Power Factor Correction Obtainable

There is another factor which must be considered, however, and that is the field strength and field heating. The design of the field windings of rotary converters varies through so wide a range that it is unsafe to attempt any general statement as to what is possible.

Most rotary converters of standard design have field windings designed to allow compounding of the converters by means of reactance on the alternating-current side. In some cases the transformers serving the converters are designed with high inherent reactance; in other cases, additional external reactance is necessary. Converters can be designed for any given amount of compounding by the use of a comparatively low value of reactance and a strong series field or by means of a high value of reactance and moderate series field. Both methods have been used. The shunt field design will vary with the relative strength of the series field. The series field will run cool enough on any converter operated within the allowable range of load for low power factor, but it is necessary to check up on the shunt field.

Probably the simplest method of doing this is to put one or more thermometers on those portions of the shunt field coils which are likely to be hottest—generally the surface about the center of the narrow space between coils. Use putty to obtain

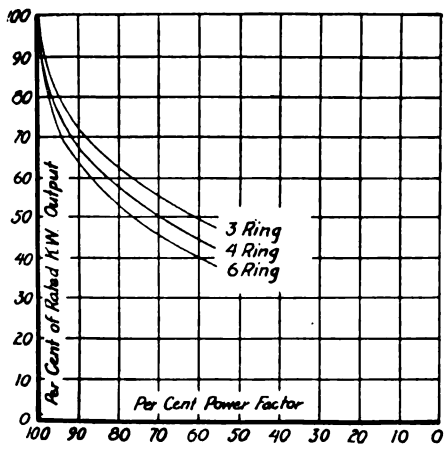
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good contact between thermometer bulb and coil, and cover the bulb well with putty. Then turn the shunt field rheostat until the resistance is all cut out, or until the alternating current delivered to the slip rings of the rotary reaches the maximum permissible value according to the curves shown in Fig. 4. It is generally the case with modern six-ring converters, operated at low power factor, that with all the shunt field rheostat cut out the slip ring current does not reach the allowable values according to the curves in Fig. 4. With the field rheostat adjusted to give the highest permissible current as per Fig. 4, or as near to this value as obtainable, continue operation of the rotary until the field surface temperature as indicated by the thermometers reaches 50 deg. C. hotter than the room temperature. Then cut in a little resistance in the field rheostat, and watch the thermometers. By trial determine the highest field rheostat setting which can be used without exceeding the 50 deg. C. rise on the field, and without exceeding the alternating-current amperes shown in Fig. 4. Mark the corresponding position on the rheostat, or better, block the rheostat sweep arm so that it cannot pass this point.

In the case of the rotaries which I used, shown in Fig. 1, the maximum power factor correction was limited by the heating of the field coils rather than by the average heating of the armature. In other words, a leading power factor alternating current of a value equal to

Fig. 2—The kilowatt load that can be carried by a rotary decreases rapidly with small departures from unity power factor.

For instance, a six-phase rotary converter operating at 90 per cent power factor can produce only 63 per cent of its rated kilowatt output without overheating the tap coils.



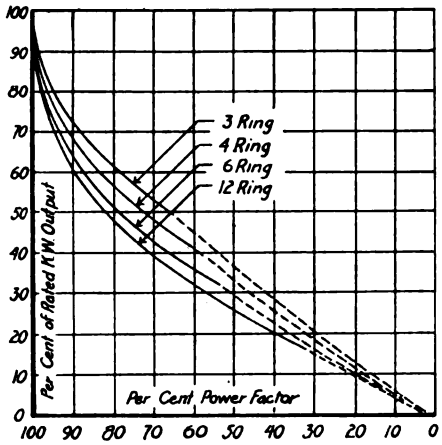


Fig. 3—Kilowatt output of rotary converters at low power factors.

These curves are similar to those in Fig. 2 except that they have been extended to include power factors down to zero. In the dotted portion of the curves the average heating of the armature, instead of the tap coil heating, governs the output. As can be seen very little kilowatt load can be carried by the rotary at low power factors.

that given by the curves in Fig. 4 could not be carried because the shunt fields of the machine overheated. It was therefore necessary to carry a little less current and obtain slightly less power factor correction.

If a worth-while corrective current, not much below the maximum safe value, is attainable, it will generally be advisable to make the best of it. If the difference is great, it is possible to remedy matters by shimming the poles, thereby reducing the air gap. This will change the compounding characteristics of the machine and is advisable only in case the man proposing to make the change has had considerable experience in such matters and is certain that the amount of shimming proposed will not render the machine less suitable for normal operation under the conditions of his particular application.

All of the preceding curves and discussions have been based on armature heating not higher than normal guarantees for continuous operation. Most modern rotary converters are designed and sold for safe operation (usually 55 deg. C rise) with two hours' operation at 150 per cent load. With corresponding operating temperature such machines will carry correspondingly heavier low power factor loads for two hours only, provided they are designed with heavy enough shunt fields. That is, machines with 2-hr., 150 per cent load guarantees will carry for 2 hr. only, half again the kilowatts and alternating-current ampere loads given in Figs. 3 and 4, so far as armature heating is concerned. Ordinarily such short-time operation at very low power factor is not called for, but in some emergency it may be helpful. For example, in case of a breakdown of one generator in an industrial power house, all the leading corrective current available may be desired for reducing the ampere load on the remaining generators during the lighting peak.

How Commutation Trouble Was Eliminated

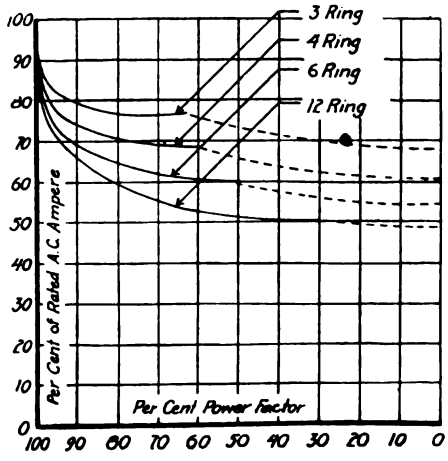
There is one other point which, although of controlling importance in comparatively few cases, deserves mention. The commutation of a rotary converter is decidedly poorer at low power factors. Full-load commutation at low power factors is often prohibitively bad, aside from all conditions of heating. However, with the conditions of operation outlined above, the amount of direct current to be commutated at low power factor is comparatively small. The machines which I used are modern, 60-cycle, compound-wound, six-phase rotaries with commutating poles. This commutation difficulty did not appear. Whether it would be a controlling feature with large machines without commutating poles I do not know.

In the case where a spare rotary is operated at zero power factor

(*Please turn to page 305*)

Fig. 4—Alternating-current ampere load of rotary converter at low power factors.

Although the kilowatt load that can be carried by a rotary when operated at low power factor is small, the alternating-current ampere load is not. For instance, a six-phase rotary will carry 54 per cent of its rated a. c. amperes at zero power factor and somewhat more at higher power factors. It was the relations shown in these curves that suggested that lightly-loaded rotaries could be used for power factor correction.



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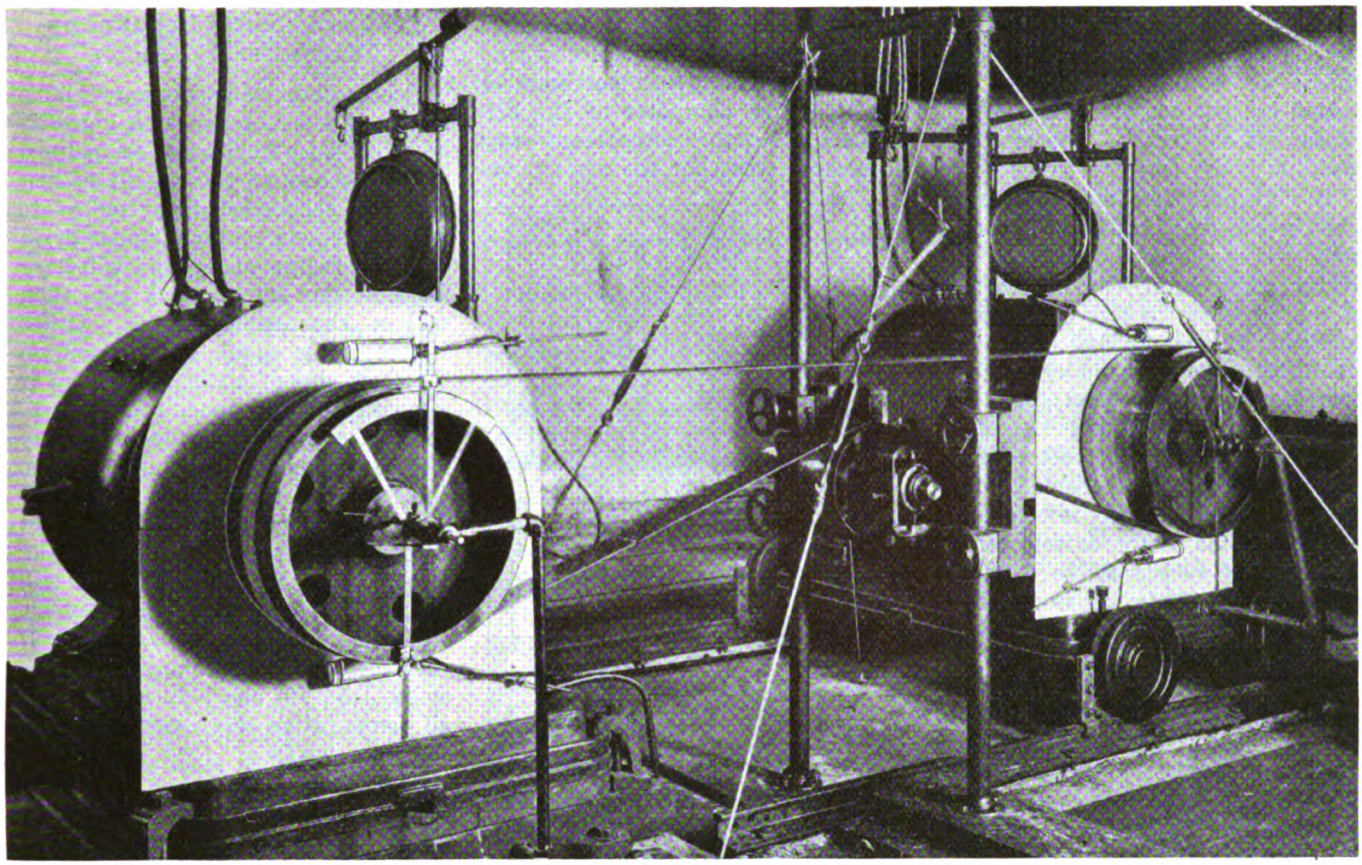


Fig. 1—This is the equipment used at Cornell University for testing belting under various conditions. It is designed so that the driving power required and the power delivered, as well as the revolutions per minute of both driver and driven pulleys, can be carefully measured.

Tests Which Show

How Service Conditions Affect Belt Capacity

Together With Tables and Charts That Will Enable Operating Men to Determine How Much Power a Belt Will Transmit, and Make Allowances Necessary in Laying Out a Drive

By R. F. JONES

Research Engineer, The Leather Belting Exchange Foundation, Cornell University, Ithaca, N. Y.

OPERATING MEN have long desired easily usable information that would enable them to lay out belt drives and make the proper allowances for the conditions which affect the power-transmitting capacity. As a part of the experimental work that has been carried on by The Leather Belting Exchange Foundation, at Cornell University, careful tests were made on horizontal belt drives to determine the effect of diameter and ratio of pulleys, center distance, high belt speed and the use of the gravity idler. The results of these tests are given here in the form of curves and tables that give the power which various weights of belt are able to transmit at different speeds, and the correction factors which indicate necessary allowances to be made for types of drive mentioned above.

MOST investigations made on the characteristics of belts in operation have taken into consideration only one set of factors or conditions affecting the power transmitted. However, belts in service seldom operate under such standard conditions as are determined by the tests. Also, most of these reports have been directed more toward the trained belting engineer than to the practical shop man in laying out belting installations under the miscellaneous service conditions found in practice.

In some recent experiments carried on at Cornell University, Ithaca, N. Y., under the auspices of The Leather Belting Exchange Foundation, the principal objective was to test belts under several standard conditions and, if possible, determine the laws under which they operated through the changes of conditions. This information was charted and a series of constants determined which are to be used as correction factors in the determination of the proper size of belt to use under different operating conditions. These tables and charts will be given and their use described later in this article.

Belt drives ordinarily fall into the two general classifications of horizontal or inclined belt drives, according to whether a line through the centers of the two pulleys is horizontal or inclined. In this determination, the study was made with horizontal drives only, under condi-

NOTE: Curves, tables and other information in this article are taken from a report made by The Leather Belting Exchange Foundation and copyrighted by The Leather Belting Exchange, Philadelphia, Pa.

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tions approximately identical to those found in industry where line-shafts or countershafts are connected by belt, or where a motor is located at the side of the shaft or machine it drives.

To determine the factors affecting the power-transmitting capacity, belts were operated under the following conditions: Varying the arc of contact with the pulley diameters constant; increasing and decreasing the distance between pulley centers; operation with large and small pulley diameters; studying the effect upon the belt capacity when using a large pulley to drive a small pulley and *vice versa*, such as is commonly used on belted motor drives; operation at belt speeds up to 8,000 ft. per min.; a study of the gravity idler such as the Lenix, Pulmax or Belt-Slacker drives.

The first tests were made to determine the effect of the arc of contact or angle of belt wrap, which is considered as the angle measured in degrees from the point where the belt comes on the pulley to the point where it leaves.

If the driver and driven pulleys are the same size the arc of contact on each pulley will be approximately 180 deg., or one-half the circumference. Should one pulley be larger than the other, the smaller one will have a wrap less than one-half the circumference, and the larger one will have greater wrap than this. Theoretically the arc of contact has an important bearing on the transmission capacity of belting; so the first step was to set up apparatus to control the arc of contact while measuring the horsepower transmitted by the belt. Fig. 1 shows how the testing apparatus was adapted to this experiment. The idler midway between the pulleys may be moved vertically, so as to hold either side of the belt up or down, to give an arc of contact ranging from 140 to 210 deg.

Numerous tests showed that the arc of contact did materially affect a belt's capacity. However, later tests on small and large pulleys approached ordinary operating conditions more closely and gave more practical data on this subject; so none of the arc of contact material will be included. These tests served to give a clearer understanding of the practical problems involved, and were of material help in later work on the effect of pulley size and pulley ratio.

This work proved that the effect on the horsepower of the arc of contact change was dependent more or less upon the character of the belt surface. Another important fact discovered was that the arc of contact, as computed for a drive by ordinary geometrical methods, does not check that obtained on the running drive. The difference between the actual angle of wrap and the computed angle depends on the belt speed, thickness, tension, pulley size, center distance, whether the tight side is above or below and whether the drive is horizontal or vertical. An easier way of taking care of the factors introduced by the use of pulleys of different sizes, which is based entirely upon experimental results, is given later in this article.

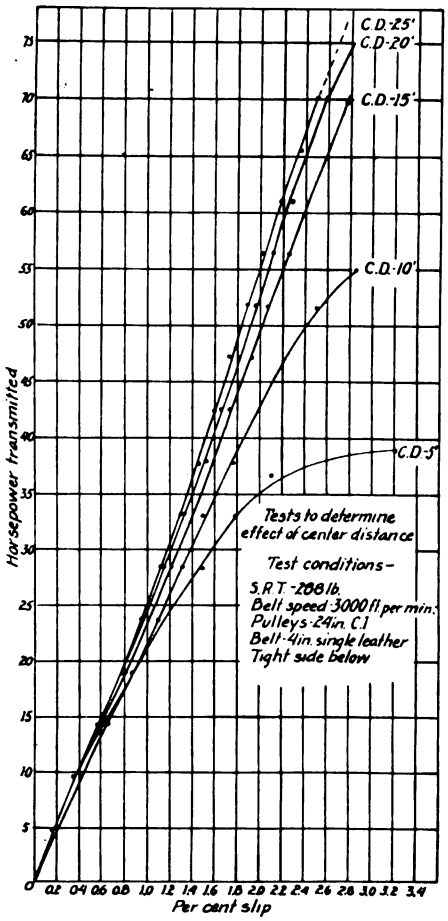


Fig. 2—The inability of short-center drives to carry heavy loads is well shown by these charts.

These tests show that a short-center drive operating under severe conditions can carry only about one-half the load of a long-center drive of the same pulley ratios. This is indicated by the curve showing the operation of a belt on a 5-ft. center distance, compared to the operation at 20- and 25-ft. center distances under a high percentage of slip. How the effect of short center distance is overcome is explained in the text, and the allowance which must be made for it is given in the tables.

Effect of Center Distance on Transmission Capacity

Center distance has an appreciable effect on the transmission capacity of a belt on a horizontal or inclined drive, because of the weight of belt material suspended from pulley to pulley. A long center distance drive when operating under load will have more tension on its slack side than will a short-center drive. Other things being equal, the tension on the slack side of a belt under load is a measure of its capacity and, therefore, a long-center drive inherently has more capacity than a short one. Experiments were made to determine how much power a belt would transmit at center distances ranging from 5 to 25 ft. The first test was made with the belt at 25-ft. centers, with the tight side below. The belt was then cut to accommodate tests at 20-, 15-, 10- and 5-ft. centers; so all comparative tests were made on the same surface.

The results obtained are given in Fig. 2 which shows the horsepower of a high-capacity belt charted against the percentage of slip for the five center distances marked on the curve. At high rates of slip, 2.75 per cent, there is a large decrease in capacity with a decrease in center distance, especially below 15 ft.; at lower slips, from 1 to 1½ per cent, the effect of shortening the center distance is much less.

How Pulley Sizes and Ratios Affect Transmitting Capacity

The diameter of the pulley is a factor in determining the operating capacity that has often been neglected, because, theoretically, the pulley size should have no effect on the belt's capacity. However, practical operating men have long known that a large pulley would pull better than a small one. It is common practice to increase the size of pulleys on drives which are giving trouble; the effect is an increase in the power-transmitting capacity of the belt which is largely attributable to the increase in belt speed.

To find the effect of the change in size of the pulley alone the shaft speed was regulated to give a uniform belt speed of 2,000 ft. per min. for all sizes of pulleys used. Cast-iron pulleys ranging from 6 to 36 in. in diameter were employed, with the driver and driven pulleys the same size in each case.

Several belts were used and in each case the capacity became

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greater as the diameter of the pulley was increased. At slips up to 2.5 per cent the 36-in. pulleys gave the highest horsepower transmission; the 24-in. came next, and so on down to the 6-in. pulley, as shown in Fig. 3. This proved that, in general, the capacity of a belt will be less on small pulleys than it is on large ones, with the greatest reduction on pulleys below 12 in. in diameter. This subject will be discussed again later and correction factors will be given to show the allowance to be made for pulley size in designing belt drives.

One of the most important phases of belt transmission is encountered in the driving of a large pulley by a much smaller one, or the opposite. Series of tests were made on six different belts to determine what transmitting capacity may be expected when pulleys of different diameters are used together. Each series consisted of five tests in which a 36-in. pulley was driven consecutively by pulleys 36 in., 24 in., 18 in., 12 in., and 6 in. in diameter. All pulleys were of cast iron. In some cases tests were made at 5-ft., with another series at 10-ft., pulley centers.

The shaft speed of the driver was regulated to give a belt speed of 2,000 ft. per min. with each pulley combination. In some instances the conditions were reversed, so that the large pulley was used as the driver, with the same results as before. Therefore, the conclusion was reached that for the same pulley sizes, the same belt capacity would obtain regardless of whether the small or the large one was driving.

Tests on a 6-in. paper pulley driving a 36-in. cast-iron pulley indicated that it transmitted about 25 per cent more power than the all cast-iron combination.

In addition to the above a series of tests was made using pulleys ranging from 4 in. to 24 in. to drive a 24-in. pulley. Up to 2 per cent slip, or within the range of low slippage, the belt transmits the highest power with the largest driver pulley and the power becomes less as the driver is reduced in size. The greatest reduction in power takes place after the driving pulley is reduced below 12 in. in diameter.

The trend of these results is shown by the set of curves in Fig. 4. Here the horsepower transmitted at 1½ per cent slip is plotted against the diameter of the smaller pulley so that one curve is given for each

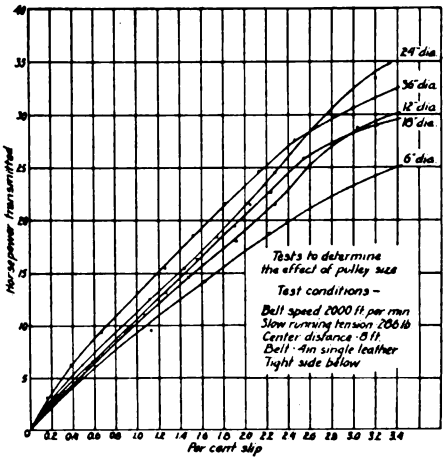


Fig. 3—The effect of pulley size is clearly shown by the results of these tests.

It is noticeable in these curves that the amount of horsepower loss increases rapidly as the diameters of the pulleys decrease. There would probably be a still greater increase of loss on pulleys below 6 in. in diameter. In this case the driving and driven pulleys are the same diameter. Extra small pulleys are not recommended for power transmission.

series of tests. The center distance and the type of belt are indicated. In each case the capacity of the belt decreases as the diameter of the smaller pulley is reduced. From this it is evident that a belt to be used on a cast-iron motor pulley of small diameter should be from 20 to 30 per cent wider than on a normal drive with large pulleys. If a paper motor pulley is used its increased capacity will tend to overcome the effect of the small pulley and not much allowance will have to be made except for motor pulleys below 6 in. in diameter, unless the driven pulley diameter is more than six times the diameter of the driver. Curves are

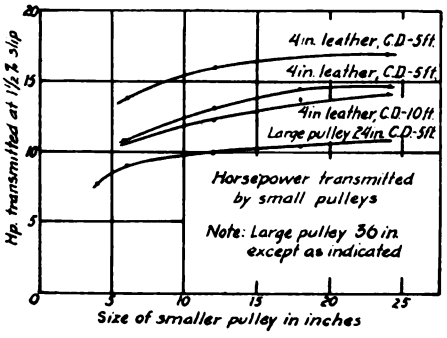


Fig. 4—This shows in another way the effect of the pulley size on the horsepower transmitted by a belt.

The rapid drop in the power transmitted where the driving pulley is below 12 in. is more clearly shown in this chart, which gives the results obtained by testing a belt under a uniform slip of 1½ per cent. This indicates that there should be some definite allowance made for small pulleys, such as are often attached to motors. The proper factors to compensate for this may be obtained either from Figs. 7 and 8 or Tables I and II.

given later in the report showing just how much to allow for cast-iron pulleys.

The work on different pulley combinations incidentally gave data on the position of the pitch line in a leather belt which is the point somewhere in the belt line that determines the working diameter of the pulley. It is common practice in figuring pulley sizes to add the thickness of the belt to the pulley diameters if a close calculation is required. This assumes that the pitch line is 50 per cent of the belt thickness out from the pulley face. Recent tests have proved that the pitch line is from 60 to 80 per cent of the belt thickness, with an average of 70 per cent out from the grain side of a single leather belt.

This is important in close speed calculations. For example, suppose a 36-in. pulley running at 200 r.p.m. is driving a machine with a 6-in. pulley through a single belt 0.2 in. thick. In computing the speed of the driven shaft, entirely neglecting the belt thickness, the method would be as follows:

$(36 \div 6) \times 200 = 1{,}200$ r.p.m. Assuming the pitch line of the belt to be out 50 per cent of the belt thickness, the belt thickness would be added to the pulley diameters and the computation would be:

$(36.2 \div 6.2) \times 200 = 1{,}168$ r. p. m. However, if the driven speed is figured on the assumption that the pitch line is 70 per cent of the belt thickness out from the pulley, 2 times 70 per cent of 0.2 in. would be added to the pulley diameters, or:

$(36.28 \div 6.28) \times 200 = 1{,}156$ r.p.m. which would be the maximum speed of this machine, neglecting slip entirely. A workman who does not understand these principles would expect to obtain 1,200 r.p.m. and would attribute the 44 r.p.m. difference to belt slippage. Even the difference between 1,168 r.p.m. as computed in the second case, and 1,156 r.p.m. might have an appreciable effect on production. Thus on drives where the driven machine speed must be closely regulated, the position of the pitch line has an important effect which should be taken into account in determining the exact pulley sizes or operating speed.

Operation of the Gravity Idler in Service

The gravity idler is a properly weighted idler, so pivoted from a long arm that the idler pulley runs

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near the small pulley against the loose side of the belt, in such a way as to increase the arc of contact on this pulley to between 220 and 250 deg. At the same time the arc of contact of the larger pulley is increased to about 215 deg. These idlers are becoming more and more popular on difficult short center drives where there is a large difference in the diameters of the driver and driven pulleys. These idlers are commonly known under the names of Lenix, Pulmax or Belt-Slacker drives.

The same testing equipment, with the addition of a gravity idler, was used here. Belts were tested on short centers of approximately 5 ft. Weights were added to the idler to produce a tension sufficient to operate at about 1½ per cent slip; each belt required a different weight.

Tests were made at a belt speed of 2,000 ft. per min. on two different belts: first, without the idler, with the tight side on the bottom; and second, using the gravity idler for comparison. A good indication of the results is plotted against the percentage of slip for two of the comparative tests. Probably the most interesting feature of the results is the unusual shape of the gravity idler curve. Instead of curving to the right and indicating an increase in the rate of slip as the load becomes greater, the idler drive curve turns up and shows that the rate of slip increase is becoming less. This curve indicates that the idler drive has a much higher overload capacity than the normal drive but that it may slip more at light loads if used on a fluctuating load, unless extra weight is used on the idler.

The arc of contact is so much greater on both pulleys with the gravity idler drive that it permits the belt to carry the same load with less tension on the bearings. In these tests the bearing tension was from 10 to 27.5 per cent less with the idler drive for the same power transmission. In practice, the tension reduction would probably be more than this because the belt on a normal drive has to be set up tighter than necessary to allow for stretch, while the gravity idler can be adjusted to give just the necessary tension.

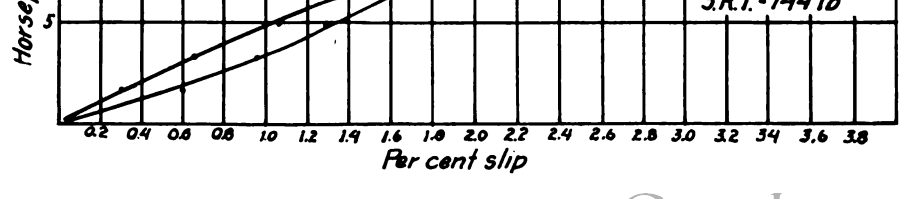


Fig. 5—Some interesting results of the tests made on a gravity idler drive.

Here the same belt drive was tested with and without an idler drive. This could easily be done because the two parts of the testing machine may be separated sufficiently to give the proper tension. The idler drive is more effective under heavy loads, where it is needed, than when the loads are light.

Effect of High Speed on Capacity of Leather Belts

The effect of high speed, with the resulting centrifugal force, has long been a source of speculation among belting men. Experiments were made at belt speeds ranging from 2,000 to 8,000 ft. per min. on several belts. Tests were made which compared single, double and triple thicknesses, throughout the above speed range; in these cases the comparative tests were all made on the same belt surface. In order to do this a three-ply belt was made up and tested. The outside ply was then stripped off leaving a double belt with the same transmitting surface. When this was tested the operation was repeated, producing a single belt. In this way all comparative tests of single, double and three-ply thicknesses were much less subject to the factor which causes the greatest experimental error: namely, variations in belt surface.

Representative results are indicated in the chart, Fig. 6, which shows a series of tests comparing a 2-in. single and a 2-in. three-ply belt. Horsepower is plotted on the vertical axis against belt speed on the horizontal axis, at a slip of 1½ per cent.

On tests on a belt which had been buffed to give it a low transmission capacity the peak loads were reached at 6,500 ft. per min. and the power transmitted decreased from that point. However, the curves, which are for a high-capacity belt, show that the peak is reached somewhere between 7,000 and 8,000 ft. per min.

In addition to transmitting more power per inch of width, a high-capacity belt has its greatest power at a high speed. A high power peak is important in the operation of a high-speed belt, because such a belt has more capacity than ordinary belts at any speed and a great deal more at high speeds. The curves on this chart, Fig. 6, furnish a good comparison of the relative capacities of single and three-ply belts. The following conclusions were drawn from this test:

(1) The speed at which the maximum power, or power peak, of a leather belt occurs, depends upon the frictional condition of the leather. A belt with

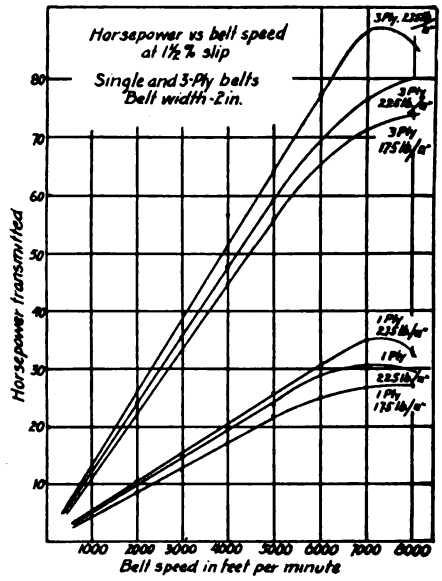


Fig. 6—These tests show that belts may be operated effectively up to between 7,000 and 8,000 ft. per min.

Other tests indicated that the power transmitted by belts with a poor surface began to drop at about 5,000 ft. per min. Also, these tests seem to indicate that the relation of capacity and speed for the various weights of belt follow definite laws. It must be remembered, however, that for high-speed operation it is necessary to have a cemented joint in the belt. These tests also show the possibility of transmitting power at speeds well beyond that at which the computed centrifugal force equals the initial testing. This value has usually been considered the absolute limit of transmission for all belts.

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a poor surface shows a peak at about 5,000 ft. per min., while a good belt might go to a maximum of 8,000 ft. per min.

(2) Belt speed seems to have about the same effect on single, double and three-ply belts; so a constant relation between their capacities can be established for all speeds.

(3) It is possible to transmit power at speeds well beyond the speed where the computed centrifugal force equals the initial tension.

Rating Charts for Leather Belting Based on Experimental Data

The above paragraphs contain a brief resume of the research work necessary to secure enough information to allow properly for the effect of the various conditions of pulley size, center distance, and belt speed. The next problem is to put the information in such form that it can be readily applied by the average person to practical belt problems. To do this necessitates the use of two curve sheets. The first of these, Fig. 7, may be considered as a series of master curves from which the horsepower per inch of width is readily obtained for any belt speed up to 8,000 ft. per min. in all weights of belt up to three ply; a separate curve, however, is used for each weight of belt.

These curves are intended to apply to local conditions only; consequently the horsepower obtained from them should be corrected for the effect of center distance and pulley size. A second chart, Fig. 8, contains three correction curves for modification of the ideal ratings obtained from Fig. 7. Two of the curves on Fig. 8 are used to correct center distance with the tight side of the belt above or below, and the other is for pulley size. The vertical axis of the chart gives the correction factors for center distances between 4 and 25 ft., and for the smaller of the two pulleys when its diameter is between 4 and 36 in. The correction factors are multiplied together and the result multiplied by the horsepower obtained from Fig. 7 to give the corrected horsepower per inch of width.

These curves take care of the effect of the arc of contact, pulley size, pulley ratio, center distance, whether the tight side is above or below, and belt speed as is explained more fully in the caption accompanying the two charts, Figs. 7 and 8. These charts are not intended for use with vertical or quarter-turn drives, as no investigations have been made under such conditions.

Many persons find that tables are much easier to use than curves, and to give these data a wider range of usefulness they have been incorporated into the tables given herewith. Table I contains the horsepower ratings per inch of width for the different weights of belts, the values having been taken directly from the chart, Fig. 7. Table II gives the correction factors for center distance and pulley diameter, and in addition multiplies them together. It is necessary only to multiply the horsepower from Table I by the correction factor from Table II to obtain the correct horsepower per inch of width. The two columns under each center distance in Table II, one marked Above and the other Below, indicate the correction when the tight side of the belt is on top (above) or on the bottom (below)

Figs. 7 and 8—These curves are used in conjunction to obtain correction factors for determining allowances, because of center distance, pulley size and whether the tight or loose side of the belt is on top, when laying out a belting installation.

If preferred, Tables I and II may be used instead of reading the values from the curves. In the use of these charts the following precautions must be observed: (*a*) These charts are to be used only on horizontal or approximately horizontal drives. (*b*) Do not use Fig. 7, at left, without the corrections from Fig. 8, at right. (*c*) The diameter of the larger pulley should not be more than six times the diameter of the smaller one. To use these curves, with these three points in mind, proceed as follows:

(1) Find the correction for center distance from one of the two center-distance curves, depending on whether the tight side is above or below. If the center distance is greater than 25 ft., use the correction for 25 ft.

(2) Find the correction for pulley size from the pulley-size curve, Fig. 8, using the diameter of the smaller of the two pulleys. If both pulleys are larger than 36 in. in diameter no correction is necessary.

(3) Choose the curve, Fig. 7, at left, corresponding to the desired weight of belt, and take from it the horsepower per inch of width according to the belt speed used.

(4) Multiply the result of (*1*), (*2*) and (*3*) together to get the corrected horsepower per inch of width.

(5) Divide (*4*) into the total horsepower to be transmitted to get the correct width of the belt.

As an example, suppose a 10-in. pulley running at 1,000 r.p.m., giving a belt speed of 2,600 ft. per min., is to transmit 15 hp. to a 36-in. pulley at a center distance of 8 ft. Assuming the tight side is below, what size of heavy single belt is required? Carrying the computations through in the same sequence as indicated, the procedure is as follows:

(1) The correction factor for 8 ft. center distance with T_1 (the tight side) below is obtained from Fig. 8 and equals 0.87.

(2) Correction factor for 10-in. pulley size from Fig. 8=0.853.

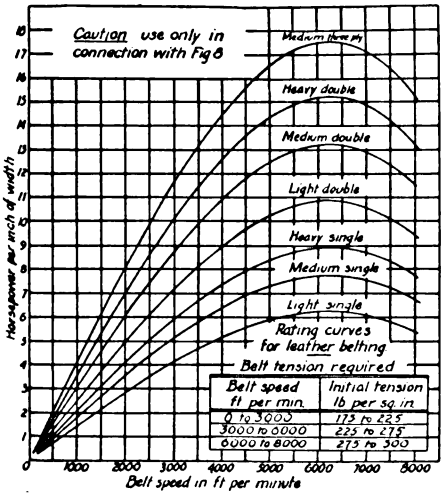
(3) Horsepower per in. width, from Fig. 7, at belt speed of 1,600 ft. per min. for heavy single belt=5.25.

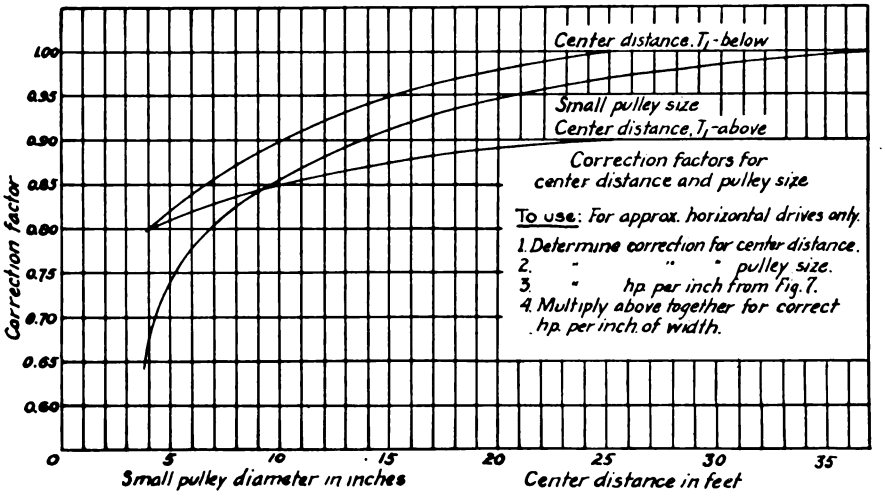
(4) Multiplying, $0.87 \times 0.835 \times 5.25 = 3.9$ horsepower.

(5) Divide 15 by 3.9=3.85, width of belt.

Therefore, use a 4-in. heavy single belt.

When the width of belt comes out an uneven size such as 3.85 in. the next larger size should always be chosen. A table of the initial tensions required for different speeds is given in Fig. 7. The tensions are given in pounds per square inch of cross-sectional area per strand of belt. The cross-sectional area is obtained by multiplying the width times the thickness, so a belt 4 in. wide and 0.2 in. thick would have a cross-sectional area of $4 \times 0.2 = 0.8$ sq. in. If the recommended tension is 175 lb. per sq. in., the tension per strand on this belt would be $0.8 \times 175 = 140$ lb.





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of the horizontal, or nearly horizontal, drive.

The biggest objection to the use of tables is that interpolation is necessary to determine quantities not given in the tables. Thus, in Table I, it was possible to give the horsepower only at intervals of 500 ft. per min.; so interpolation will often be required. In doing this, it is advisable to use the nearest 50 or 100 ft. per min. If the belt speed is below 500 ft. per min. it would be better to use the nearest 25 ft. per min. in order to reduce the percentage of error. The explanatory caption in connection with these Tables gives an example of each step of an easy method of interpolation for Table I.

Enough values are given in Table II for correction factors so that interpolation will seldom be necessary and, when it is, the correction can usually be estimated closely enough for all practical purposes. These tables are subject to the same limitations that are imposed on the curves in Figs. 7 and 8.

The following explanation of assumptions on which these curves are based may assist practical men in obtaining a more complete understanding of belts and belt operation. The set of curves in Fig. 7 are based on two principles. The first is, that the rate of slip in ft. per min. should increase with the belt speed, but that the percentage of slip should decrease. Therefore, a belt performing in accordance with this assumption should slip about 1.5 per cent up to 2,000 ft. per min., 1.25 per cent at 3,000 ft. per min., 1 per cent at 4,000 ft. per min., 0.9 per cent at 5,000 ft. per min., 0.8 per cent at 6,000 ft. per min. and 0.75 per cent at 7,000 to 8,000 ft. per min. The second principle is that speed affects the various thicknesses of leather belting in the same way, so that definite ratios between the capacity of the different thicknesses can be established which will hold true for all speeds. In terms of medium-single belt the following ratios were used: light single, 0.81; medium single, 1.00; heavy single, 1.15; light double, 1.40; medium double, 1.70; heavy double, 1.95; medium three-ply, 2.25. It is assumed that the initial tension should be applied in proportion to the belt thickness, as given in the government specifications for all weights of belts.

The center distance curves, Fig. 8, which are based on these experiments, are constructed so as to give proper center distance allowance for a belt of average capacity. There was not as much variation as this on a low-capacity belt, but considerably more on a high-capacity belt; so the curves are a compromise between the two. The effect of center distance with the tight side on top is

(*Please turn to page 305*)

Table I and II—Where desired, these tables may be used in determining rating of leather belting instead of Figs. 7 and 8.

Suppose, for example, that it is desired to find the horsepower for a medium single belt operating at 2,860 ft. per min. The procedure is as follows:
(1) Choose values of horsepower for nearest speeds, one higher and the other lower than the given speed. Example: If given speed=2,860 ft. per min., use 2,850 ft. per min. Horsepower at lower table speed, which is 2,500 ft. per. min.=4.35. Horsepower at higher table speed, which is 3,000 ft. per min.=5.15.
(2) Subtract lower table speed from given speed and divide by 500. Example:
2,850—2,500=350.
350÷500=0.7.
(3) Subtract lower table horsepower from higher table horsepower. Example: 5.15—4.35=0.80 hp.
(4) Multiply results of (2) by (3). Example: 0.7×0.80 hp.=0.56 hp.
(5) Add result of (4) to lower table horsepower for correct value of hp. per inch of width from Table I. Example: Correct horsepower for 2,850 ft. per min.=4.35+0.56=4.91 hp.

Table I—Horsepower Transmitted by Belts Per Inch of Width at Different Speeds

Weight of Belt	Belt Speed in Feet per Minute															
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
Light Single	0.75	1.45	2.16	2.87	3.53	4.15	4.70	5.20	5.60	5.95	6.20	6.30	6.30	6.15	5.85	5.45
Medium Single	0.90	1.80	2.68	3.55	4.35	5.15	5.80	6.42	6.95	7.35	7.62	7.78	7.75	7.57	7.25	6.76
Heavy Single	1.05	2.06	3.10	4.10	5.05	5.93	6.70	7.40	8.00	8.42	8.75	8.92	8.92	8.75	8.36	7.76
Light Double	1.25	2.53	3.76	4.95	6.10	7.17	8.12	9.00	9.70	10.30	10.70	10.92	10.90	10.65	10.16	9.48
Medium Double	1.52	3.08	4.60	6.00	7.40	8.70	9.90	10.95	11.82	12.50	13.00	13.22	13.20	12.90	12.35	11.55
Heavy Double	1.77	3.55	5.30	6.95	8.55	10.05	11.45	12.60	13.60	14.35	14.92	15.22	15.20	14.85	14.20	13.20
Medium Triple	2.05	4.10	6.10	8.05	9.88	11.60	13.15	14.50	15.62	16.52	17.20	17.55	17.5	17.10	16.40	15.30

Table II—Correction Factors Which Compensate for Center Distance and Pulley Diameter

Dia. of Smaller Pulley Inches	Center Distance in Feet															
	4		6		8		10		12		15		20		25	
	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
4	0.53	0.53	0.54	0.55	0.55	0.57	0.56	0.59	0.57	0.61	0.58	0.63	0.59	0.65	0.59	0.66
5	0.59	0.59	0.60	0.62	0.62	0.64	0.63	0.66	0.63	0.68	0.65	0.70	0.66	0.72	0.66	0.74
6	0.62	0.62	0.63	0.65	0.65	0.68	0.66	0.70	0.67	0.72	0.68	0.74	0.69	0.76	0.70	0.78
8	0.66	0.66	0.67	0.69	0.69	0.72	0.70	0.74	0.71	0.76	0.72	0.78	0.73	0.80	0.74	0.82
10	0.68	0.68	0.70	0.71	0.71	0.74	0.73	0.77	0.73	0.79	0.75	0.81	0.76	0.83	0.77	0.85
12	0.70	0.70	0.72	0.74	0.73	0.77	0.75	0.79	0.76	0.81	0.77	0.83	0.78	0.86	0.79	0.88
15	0.73	0.73	0.74	0.76	0.76	0.79	0.77	0.82	0.78	0.84	0.80	0.86	0.81	0.89	0.82	0.91
18	0.75	0.75	0.76	0.78	0.78	0.81	0.79	0.84	0.80	0.86	0.82	0.89	0.83	0.91	0.84	0.93
24	0.77	0.77	0.79	0.81	0.81	0.84	0.82	0.87	0.83	0.89	0.85	0.92	0.86	0.94	0.87	0.96
30	0.79	0.79	0.81	0.82	0.82	0.86	0.84	0.89	0.85	0.91	0.87	0.94	0.88	0.96	0.89	0.98
36	0.80	0.80	0.82	0.84	0.83	0.87	0.85	0.90	0.86	0.92	0.88	0.95	0.89	0.98	0.90	1.00

Directions for Use of Horsepower Rating Tables for Leather Belting—1. Determine horsepower per inch of width from Table I. 2. Determine correction factor from Table II. 3. Multiply values from Tables I and II together for correct horsepower per inch. 4. Divide total horsepower to be transmitted by horsepower per inch to get required width of belt.

Note—(A) Above and below in Table II refer to the position of the tight side. (B) When interpolating for speeds not given in Table I use nearest 50 or 100 ft. per min. For example: If belt speed is 1,665 ft. per min., use 1,650 ft. per min., or if it is 1,690 ft. per min. use 1,700 ft. per min. (C) If the center distance is over 25 ft. use 25 ft. in Table II. If the smaller pulley is over 36 in. use 36 in. in Table II. (D) Use only on horizontal or nearly horizontal drives.

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SWITCHBOARDS are the nerve-centers of electrical distributing systems and as such have to perform a number of important functions. The proper discharge of these functions and the maintenance of continuity of service to the electrically-driven equipment depend to a large extent upon the materials of which the switchboard is constructed and the manner in which these materials are assembled. In this article, Mr. Notvest outlines the essential characteristics which should be possessed by materials suitable for use in switchboards and discusses the use of slate for this purpose. Also, he gives helpful suggestions on how to select and handle slate.

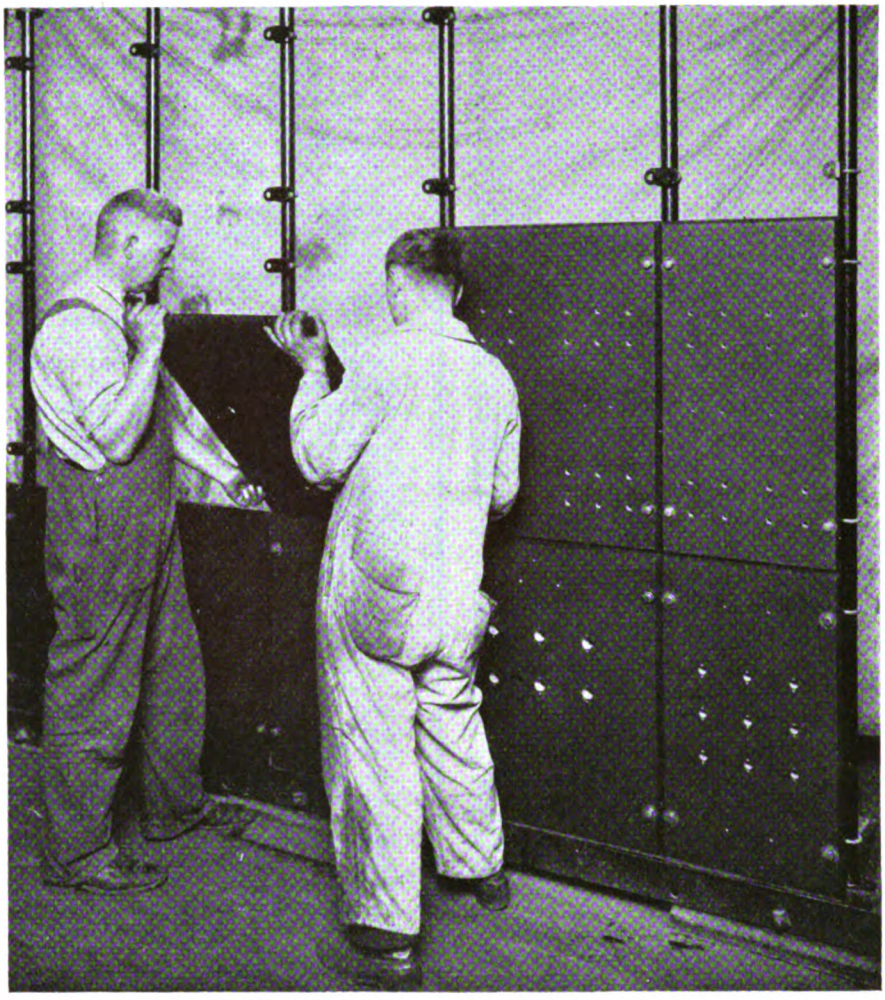
Practical Pointers on the Use of

Slate as a Switchboard Material

With Specifications for Its Purchase and Suggestions on How to Install It So as to Secure the Best Service Therefrom

By ROBERT NOTVEST

Consulting Engineer, The Structural Slate Company, Pen Argyl, Pa.



Properly locating the holes for the bolts will do much to facilitate the assembly and alignment of the slate panels on a switchboard. This illustration shows the proper method of putting the panels in place. Care must be taken to see that the bottom panels rest on a substantial base and that the upper panels rest on those below them, so that their weight is not supported by the holding bolts.

FOR a clear understanding of the basic requirements which any given switchboard material must meet in order to secure the uninterrupted distribution of electrical energy, it may not be amiss to define the functions of such equipment as switchboards, panelboards, and industrial control equipment on which slate and similar materials are employed for the permanent mounting of the component devices.

Switchboards and panelboards are the assembly of such devices as switches, circuit breakers, rheostats, oil switches, contactors and relays, which permit, either through manual or automatic operation, the distribution of electrical energy. In addition, they combine with the means of connecting and disconnecting circuits, the necessary instruments for measuring the quantity of electrical energy distributed to the various circuits, and for protecting automatically, through relays, fuses, circuit breakers, oil switches, resistances and reactances, the generating station from the destructive effects of overloads, short-circuits, grounds and various other troubles and conditions which may arise and cause serious damage not only to the generating machinery and the distribution system, but also to the equipment which uses electrical power. While switchboards and panelboards have the function of protecting and regulating the distribution of electrical energy as such, industrial control apparatus can be defined as switching and protective gear used in connection with an electric motor, forming an essential part thereof to secure the proper performance required of the motor.

Characteristics Which a Switchboard Material Must Possess

It may be interesting to consider for a moment some of the essential characteristics which any material used for the construction of switchboards and panelboards, for mounting industrial control equipment and so on, should possess, so that industrial plant men who are called upon to select or build such equipment may go about their task more intelligently.

(1) Switchboard material must be a good insulator; that is, a substance which will in greater or less degree confine the electric current and force it to traverse a predetermined path. We must define the term electric insulation as embracing in its meaning three important functions which must be fulfilled before any material can be utilized for safely and permanently confining electrical energy. These functions are: (1) Dielectric constant, or specific inductive capacity. This should not vary excessively under changes of temperature or potential. Although this quality is, for many insulating materials, fairly constant under direct-current potentials, under alternating-current pressures it becomes erratic and is greatly affected by changes in temperature or frequency. In the case of composite dielectrics it is also affected by the inherent characteris-

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tics of each component dielectric and its individual peculiar factor of transient capacity absorption. (2) Resistivity or insulation (ohmic) resistance. A high value is invariably desirable, to prevent leakage. (3) High dielectric strength, to prevent mechanical rupture or breakdown under high potential stresses.

A high degree of purity of the insulating material is another prerequisite, as even under constant electrostatic pressure minute impurities may cause a considerable increase in the flow of leakage current. High porosity of an insulating material may not only greatly decrease insulation resistance, through an initial content of moisture, but also produce this condition by reabsorption. The surface resistance of an insulator is, in turn, greatly influenced by the finish of the material and the humidity of the atmosphere at the place of installation. Experimental data so far obtained seem to indicate that failure or rupture in a dielectric is of a progressive nature; that is, the final disruptive failure is preceded by a continually increasing conductivity due to cumulative overheating.

(2) The material must possess sufficient strength to bear, without danger of breaking or bending, the weight of heavy instruments, switches, circuit breakers, and so on. The compressive strength must likewise be high. The importance of this is seen from the fact that panels in general are screwed or bolted tightly against four or six irregular points of contact on the angle-iron or pipe frame. In the vast majority of cases the contact surfaces do not correspond to a true plane and distortional stresses are set up when the panel has to be forced to conform to the irregularities of the framework. Furthermore, circuit breakers and switch studs, especially in the large sizes, are tightened down very hard. Great compressive stresses are also caused by the leverage of oil switches, motor starters, rheostats and heavy instruments when mounted directly on the panel.

Recommended Specifications Covering Purchase of Slate for Electrical Purposes

(1) Such slate shall be of clear mill stock, uniform in color, free from veins, spots and cracks, of uniform dense texture with specific gravity of approximately 2.8. The percentage of absorption of water by weight in 24 hours shall not be greater than 0.3 per cent.

(2) All slate shall have the following physical characteristics: Tensile strength, approximately 3,500 lb. per sq. in. Compressive strength, not less than 10,000 lb. per sq. in. Modulus of elasticity, 8,000,000 lb. per sq. in. Toughness, that is, resistance to fracture under impact, shall be determined under the method advocated by the American Society for Testing Materials, and show a factor of not less than 12.

(3) All slate shall be easy to drill and shall not be used for electrical purposes until three months from date of quarrying.

(4) The face, and edges of panels shall have even, true surfaces, accurately cut to dimensions given and shall not vary more than $\frac{1}{16}$ in. Any adjoining edges or sides shall not deviate from a right angle by more than $\frac{1}{32}$ in. Bevels shall be cut true entirely around panels and shall be measured by the projected width and depth. The back of the panels shall be free from lumps or depressions, but need not be trued.

(5) All slate shall be tested prior to shipment with 2,200 volts alternating current and the impedance leakage actually measured by means of either a wattmeter in the primary of the transformer used, or by the voltmeter method of determining the voltage drop in a transformer of given capacity, or with a milli-ammeter in series with the high-tension circuit. The impedance leakage shall not exceed such limit in milli-amperes as may be determined to be expedient for the particular application.

(6) Holes drilled in the slate for the purpose of securing it to the supporting angle irons or pipe framework shall be from 15 per cent to 20 per cent larger in diameter than the screws, bolts, capscrews or studs used for this purpose. Also, between the surface of the slate and the points of contact on the supporting framework there shall be interposed compressible washers of suitable size of such material as rubber, leather, felt, fibre, etc., to compensate for the irregularities of the surface of the framework.

(7) Slate slabs over 4 sq. ft. in area, mounted on framework shall rest on an angle-iron support, so that whenever possible the fastening bolts, screws or studs do not carry the weight of the slate, but only hold the same in place. In the case of large switchboard assemblies, all panels shall rest on a substantial channel-iron base, preferably cushioned with a strip of the above-mentioned compressible material between the slate and the base.

(3) The material must possess a certain amount of elasticity. Switchboards by necessity have to be installed in such locations that they are constantly subjected to vibration and jars from the equipment which they control. In the field of industrial control apparatus such applications as protective panels for cranes, hoists or elevators, automatic motor starters on machine tool service, and so on, are instances where the switchboard material is subjected to shocks and severe vibrations and must have a high factor of elasticity.

(4) Sufficient toughness to withstand the service conditions to which it is subjected, is essential. The general tendency of industrial plants to use motor drives, has opened up a wide field for automatic motor starters of various designs, and switchboard material of considerable toughness is required in order to stand up under the heavy impacts

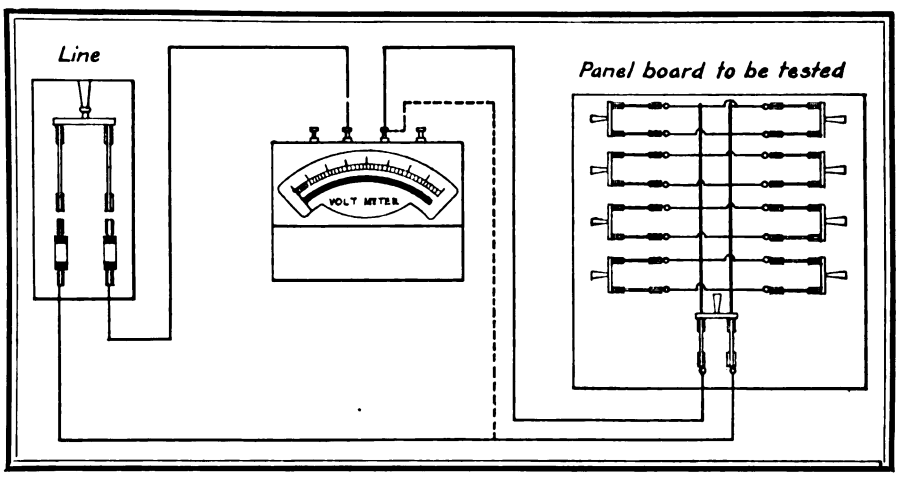


Fig. 1—Connections for determining insulation resistance of slate panel by voltmeter method.
The line voltage is measured with the voltmeter connected as shown by the dotted line; then the voltage is again measured with the dotted connection removed. The resistance of the voltmeter can be obtained from the instrument and, with these three quantities known, the resistance of the panel can be calculated by the use of a simple formula, as explained in the text.

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caused by the opening and closing of the magnetic switches and contactors.

(5) Material used for electrical insulating purposes must be practically non-absorptive. Due to the wide range and quick variation in temperature to which electrical apparatus is subjected, there is very often a danger of leakage due to surface condensation and moisture.

(6) The expansion with rise of temperature should be so slight as to avoid the possibility of setting up destructive stresses with changes of temperature.

Coming now to the materials that possess the above qualities in sufficient degree to warrant their use, or consideration, for such purposes, slate is widely used for mounting both switchboards and industrial control apparatus. Other materials used for switchboard and similar construction are marble, either the Blue Vermont or Pink Tennessee variety; synthetic substitutes in the form of boards made from asbestos and magnesia fiber mixed with hydraulic cement, compressed into shape and saturated with an asphalt compound; natural, fine-grained sandstone boiled in linseed oil; opaque black glass; and metal, as in the so-called all-metal, safety dead-front construction.

Composition and Properties of Slate for Electrical Use

Before discussing the properties of slate which make it valuable for electrical purposes, it may be well to consider what slate is and where it is obtained. Slate is a natural, fine-grained rock which possesses fissility or cleavage, the ability to be readily split along a certain direction. Briefly, slate is composed largely of chemical combinations of silica with aluminum and iron or magnesium, with varying, although small, amounts of other minerals or compounds including iron oxide and sulphide, graphite, and so on.

Roofing and structural slate is found in several states in the eastern, western and southern portions of this country. Usable electrical slate has, however, so far been found only in certain quarries in Vermont, Maine and Pennsylvania. The first step in extracting slate from its bed is to cut deep vertical grooves in it by channeling machines. These grooves are 6 or 8 ft. deep and spaced 6 to 10 ft. apart. After the channeling machines have cut the grooves, the slate is split by means of wedges into slabs 6 in. or more thick and removed from the quarry. Along with the good material there is a large amount of small pieces and waste that must also be removed. The average amount of waste in a quarry is 75 per cent of the total amount of material taken out.

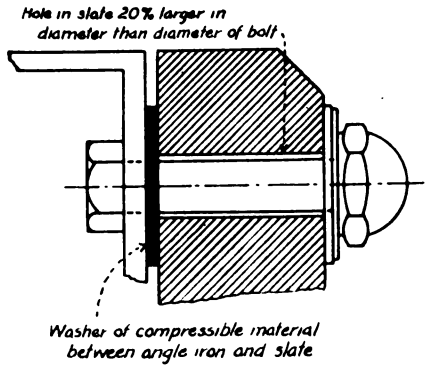


Fig. 2—Bolt holes in slate panels should be about 20 per cent larger than the diameter of the bolt.

Drilling the holes 15 or 20 per cent larger than the bolts will make assembly and alignment easier, and give some leeway for expansion or contraction of the panel. It is also good practice to place a washer of leather, fiber or other compressible material between the slate and the angle iron in order to lessen distortional stresses when the structure is tightened up.

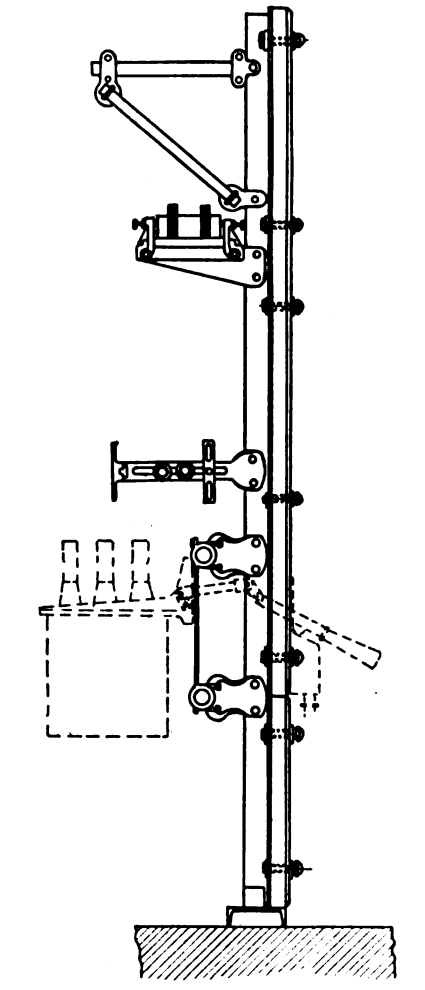


Fig. 3—The weight of the slate panels should be carried by a channel-iron base.

If the studs or bolts are allowed to carry the weight of the panels, the slate may be damaged. When the switchboard is subjected to much vibration or shocks it is advisable to place a strip of rubber packing or similar material between the slate and the angle-iron or channel-iron base. This illustration shows a typical oil switch assembly on a slate panel.

There are three main divisions in the uses of slate: roofing, structural, including electrical, and blackboards. If the slate can not be used for one of these purposes it should be suitable for either of the other two. The cost of extracting and finishing slate for any one of the three possible uses alone would make it so costly that it could not be marketed commercially.

After removal from the quarry the slabs which are usable for blackboards and structural purposes are taken to a mill and cut by large steel saws into the sizes required. From these slabs those which may be used for electrical purposes are selected, and split into the desired thickness. The surface of the resulting slabs is fairly even, but rough. The next operation is planing both sides; this gives an even surface which shows the marks of the planes. This planed surface is always left upon the back of slate used for electrical purposes, unless otherwise directed.

Following the planing operation, the slate is given one of two standard finishes. The so-called sand-rubbed finish is produced by rubbing the surface with sand and water. The resulting surface is smooth and even, showing a slight grain or stipple. This finish is sometimes called for on electrical slate, although in most cases the honed finish is preferred and is, therefore, furnished as standard. This finish is produced either by rubbing the slate with blocks of carborundum, with a stream of water running over the surface, or by smoothing the surface with a belt which is charged with fine carborundum and travels over the surface at a speed of 3,000 ft. per min. Unless otherwise specified the honed finish is always furnished on electrical slate.

There are four usual methods of treating slate panels, to produce the oiled, black marine, enamel, and marbleized finishes. These finishes are usually applied before complete installation, but if desired can be applied before shipment, although this must be specified.

The oiled finish consists of raw linseed oil rubbed in. It can be ap-

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plied after all work of drilling is completed and gives the slate a clear black color. After installation and during constant use the color can, if necessary, be readily brought back by rubbing in a small amount of oil. This is the least expensive of all of the finishes.

The black marine finish was originated and is required by the U. S. Navy Department upon the electrical installations aboard warships, from which it derives its name. It is produced by the application of an amyl-acetate lacquer colored with black aniline dye, and is a dead black color. This finish gives a moisture-proof surface which has the peculiar quality of causing all water upon it to evaporate quickly. It is a long-lasting finish of good appearance and is called for frequently in electrical specifications where there is danger of moisture. This finish will not show stains from oil.

If any special tints or colors are required upon slate, it is possible to produce these satisfactorily by the use of lead and oil paint, which adheres well to the stone. The specifications for this painted finish may follow good accepted local practice, the same as for metal or wood, although it is not recommended that less than three coats be used and more properly four. If desired, it is possible to secure stained effects by the use of stains or wax, which should be applied and rubbed in with a cloth. In this way it is possible to secure a lighter effect, somewhat gray in color.

A large amount of investigational work has been done in determining the physical properties of slate, particularly with reference to its use in electrical installations, and for the sake of those who may be called upon to make use of this material, a brief resume of the results of these tests will be given. These tests were made on representative samples of slate of a grade suitable for use in switchboards and similar installations. For convenience, we may use the outline given above for the essential characteristics which switchboard material should possess.

Insulating Value—The average resistance of newly-quarried slate has been found to be on the order of 734,750 ohms per cu. in. Freshly-quarried slate contains a certain amount of moisture as a part of its crystalline structure. The influence of this moisture in reducing the resistance is shown by the fact that the average resistance of slate quarried three months is 2,535,700 ohms per cu. in.

The particular problem of the Pennsylvania producers has been to weed out of the quarry material containing an excess of carbonaceous or conductive material. Today, the quarries are testing every single slab of slate to be used for electrical installation prior to shipment with 2,200 volts and actually measure the impedance leakage. The apparatus used is an especially-designed test set which is covered by patent application. It consists of a step-up transformer in which the short-circuit current is limited to a predetermined safe value by means of a suitable resistance or reactance in the primary. This arrangement, through a corresponding adjustment in the ratio between primary and secondary coils, prevents an excessive voltage drop on slight leakage currents. A special, uniform-scale, dynamometer type of milli-ammeter is connected in series with the secondary of the transformer.

The tolerance limit of impedance leakage under a potential of 2,200 volts alternating current has been set at 20 mil.-amp., as slate at the quarries is by necessity tested while still containing moisture. Practical experience has shown that slate containing an excess of carbon gives leakages far in excess of this amount, and that slate still containing moisture as part of its crystalline structure and giving readings within the limits of the above-mentioned tolerance will, when dried out, give a leakage of only 2 to 5 mil.-amp. under 2,220 volts a. c.

Tensile Strength—Data regarding

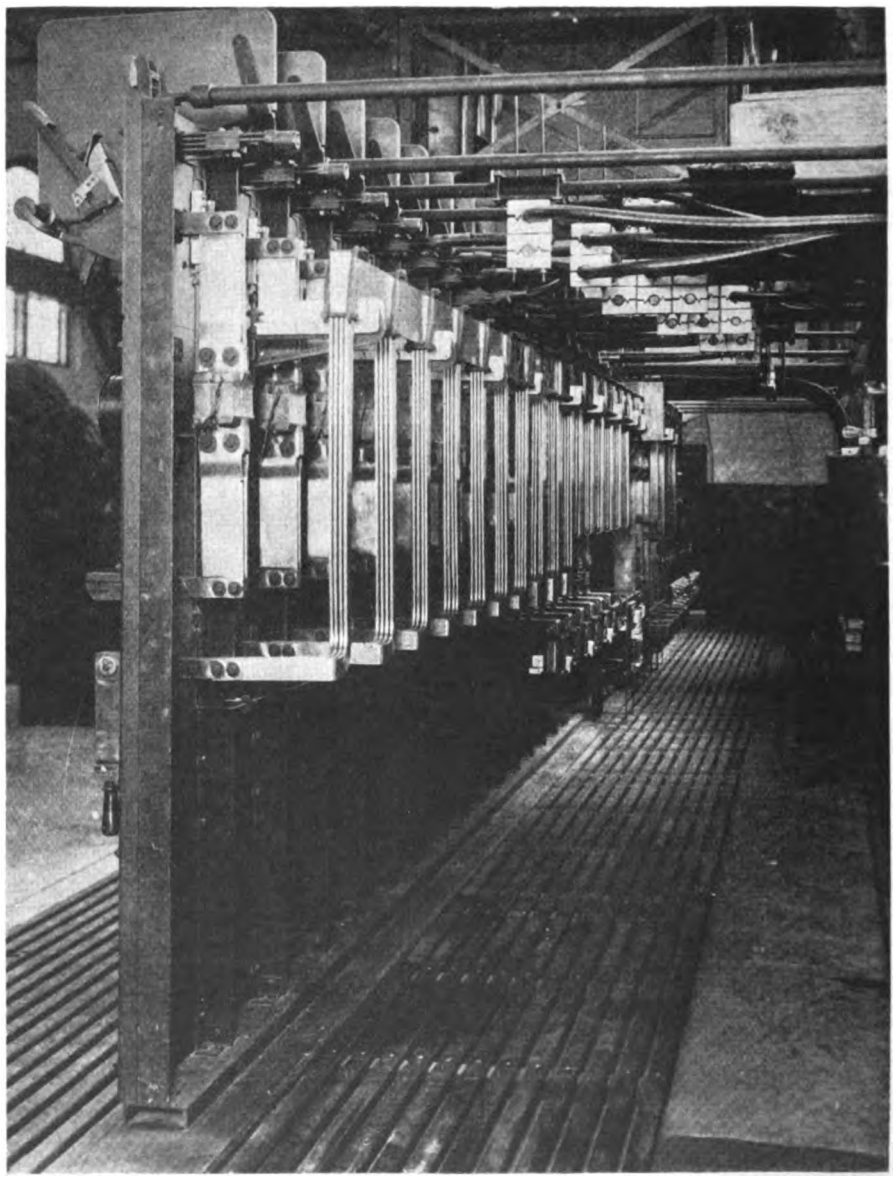


Fig. 4—Here is a switchboard which is properly mounted on a channel-iron base.
This base carries the weight of the slate panels, so that none of it comes on the holding bolts. The arc shields between the circuit breakers on this switchboard are also made of slate.

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the tensile strength of slate is seldom required. However, as a matter of information tests made upon 19 samples showed an average tensile strength of 3,625 lb. per sq. in.

Tests of the compressive strength made on a large number of samples of Pyramid brand slate showed on the average 10,250 lb. per sq. in.

Elasticity—This property was determined by several series of tests in which samples of slate 26 in. long, 1 in. wide and ½ in., 1 in. and 1½ in. thick respectively were arranged as beams on wood supports 24 in. apart. A load was applied at the center of the span and the deflection and breaking point noted. The following results are the averages of a number of tests: Beams ½ in. thick: average load at failure 68 lb.; average deflection 0.094 in. Beams 1 in. thick: average load at failure, 239 lb.; average deflection 0.0638 in.; modulus of elasticity, 9,437,000. Beams 1½ in. thick: average load at failure, 685 lb.; average deflection, 0.0793 in.; modulus of elasticity, 7,912,000.

Toughness—In testing slate for toughness, the method recommended by the American Society for Testing Materials has been used. Toughness, as applied to rock, is the resistance to fracture under impact, expressed as the final height of the blow of a standard hammer required to cause fracture of a cylindrical test specimen of given dimensions. A number of specimens of slate tested gave an average height of 11.5 cm. (4.5 in.).

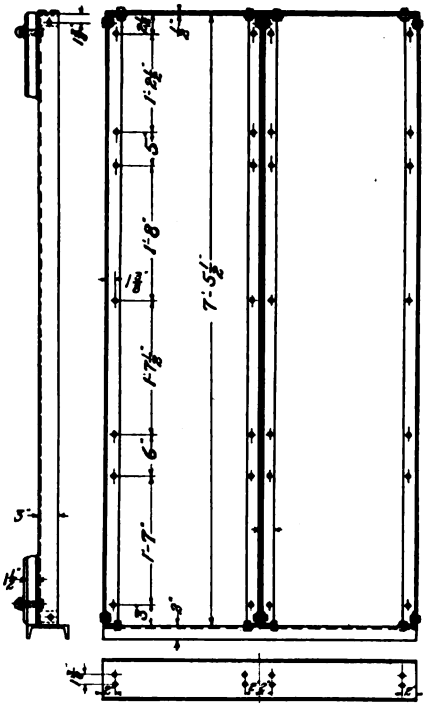
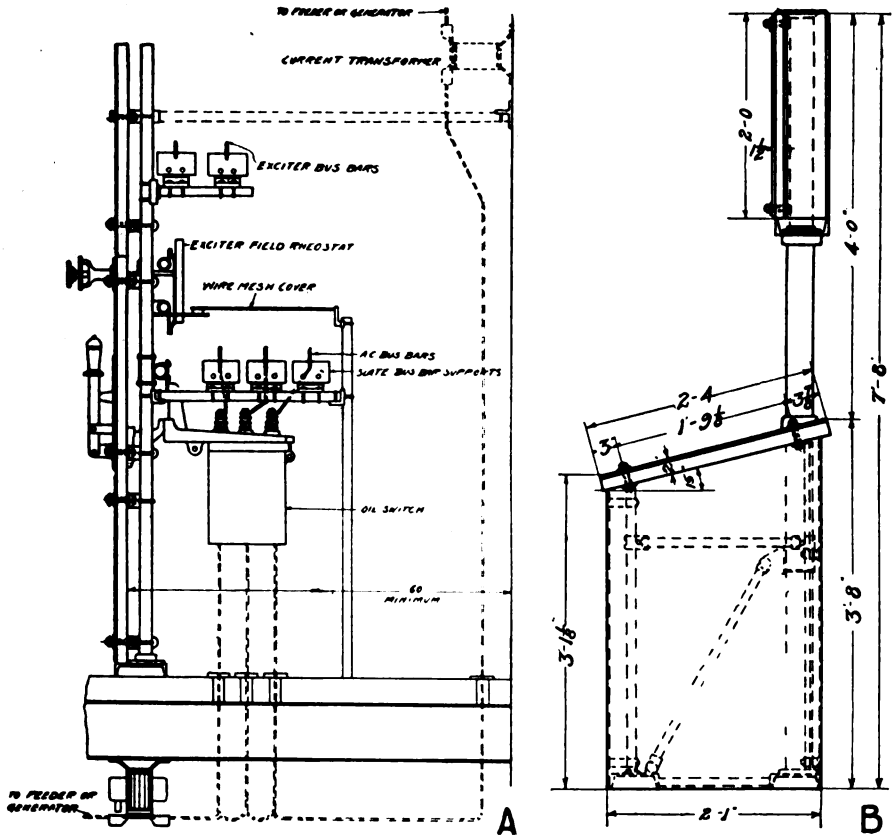


Fig. 5—Here is a typical angle-iron switchboard frame.
The dimensions shown here could easily be altered to suit local conditions.

Fig. 6—These are typical details of A, pipe-frame switchboard assembly and, B, a benchboard frame.
Note the channel-iron base on which the panel in *A* rests. The benchboard frame in *B* also rests on a channel iron. The compressible washers, between the slate and the frame are clearly shown in both of these illustrations. One of these washers is shown in detail in Fig. 2.



Absorption—This quality was determined by baking representative samples at a temperature of 120 deg. C. for 24 hr. and weighing. They were then immersed in water for 24 hr. and weighed again. Under these conditions, the average increase in weight was found to be 0.196 per cent of the dry weight.

Expansion—A large number of samples tested in an electric furnace at temperatures ranging from 10 deg. to 200 deg. C showed on the average a co-efficient of expansion of 0.00001.

For practical purposes, these results are embodied in the accompanying specifications. These specifications can be used without prejudice for slate originating in Vermont, Maine, or Pennsylvania and call for the physical characteristics which are absolutely essential in material that is to be used for electrical appliances.

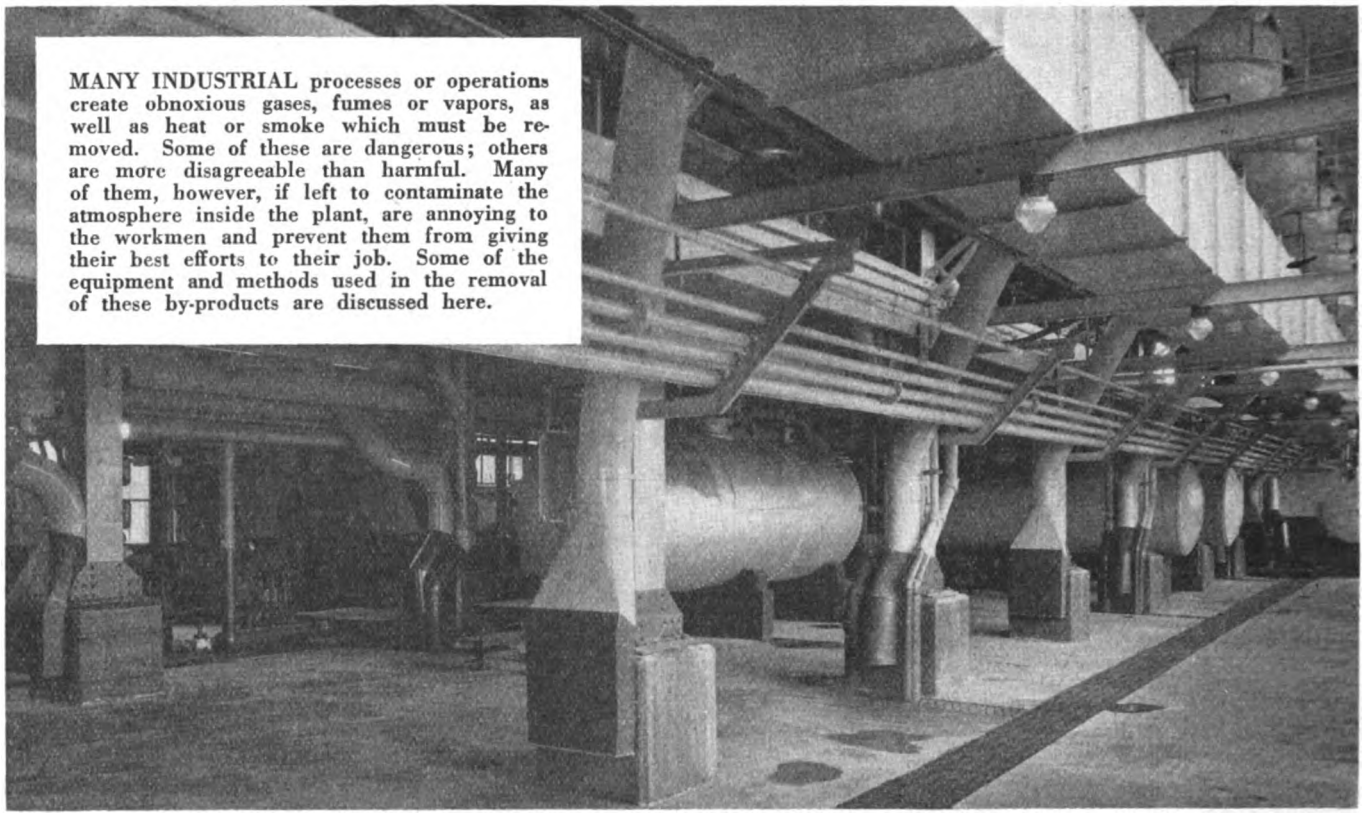
Method of Measuring Insulation Resistance of Slate Panels

In some instances it is desirable to determine the insulation resistance of a slate panel in service. This can be done in various ways, such as by means of a direct-reading ohmmeter, a Wheatstone bridge, or a milli-ammeter, although in practical work the most convenient instrument is the ordinary high-resistance voltmeter. The connections for determining the resistance by means of a voltmeter are shown in Fig. 1.

The theory of the voltmeter method of measuring insulation resistance is as follows: When a current flows through two conductors in series the volts drop across each of the conductors will be proportional to the resistance of that conductor. Then with an unknown resistance, *Rx*, connected in series with the voltmeter across the source of potential the volts drop across *Rx* will be proportional to its unknown resistance. Also, volts drop *Vv* across the resistance of the voltmeter, as indicated by the reading of the instrument itself, will be proportional to the resistance of the voltmeter. The proportion may be written Vv÷Vx =Rv÷Rx, or Rx (in ohms)=(Rv× Vx)÷Vv. In these formulas, *Vv* is the voltage drop across the

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MANY INDUSTRIAL processes or operations create obnoxious gases, fumes or vapors, as well as heat or smoke which must be removed. Some of these are dangerous; others are more disagreeable than harmful. Many of them, however, if left to contaminate the atmosphere inside the plant, are annoying to the workmen and prevent them from giving their best efforts to their job. Some of the equipment and methods used in the removal of these by-products are discussed here.

When fumes or vapors are heavier than air they settle to the floor and so exhaust outlets must be placed low. Here at the Deepwater Point du Pont Dye Works the floor suction openings discharge into the square duct overhead. Fresh air is discharged from round pipes overhead.

Some Things It Pays to Know About

Removing Obnoxious Fumes, Gases and Vapors

Which Are Generated During Industrial Processes, Together With a Discussion of Equipment and Methods Commonly Used

By CHARLES L. HUBBARD

Mechanical Engineer, Boston, Mass.

REMOVAL from manufacturing plants of objectionable substances, such as fumes, gases or dusts, whether in the atmosphere or created by the industrial processes, together with some of the lighter-weight materials, has become a matter of importance and in many cases of legislation or factory inspection regulations which specify the manner and operation of such removal. This is a problem which has wide distribution among various industries and a general consideration of its ramifications as well as methods of solution would seem to be of interest to industrial plant men.

The first point to take into consideration in the removal or repression of all of these objectionable substances is that they will, for a time at least, remain suspended in air. Naturally, it may be expected that a sufficient supply of fresh air, together with adequate removal of the impure air, partially or wholly saturated with the gases, fumes, vapors, dust or other objectionable material, will take care of practically any problem. This is the case; the exception is where the so-called fresh air is also contaminated with dust or some odor. The problem of the industrial man is to so direct this draft of fresh air as to remove the impure air in the most economical way and in such a manner as to interfere the least with the industrial processes or operations involved. If this point is kept in mind in planning for the removal of these undesirable industrial creations, the problems will be much simplified.

The equipment for handling these substances varies somewhat according to their nature, and final details of construction are frequently best left to those making a specialty of this class of work. Manufacturers of equipment for the purpose generally offer advisory or consulting service in connection with the installation of their equipment. The superintendent or engineer in charge, however, should be familiar with the characteristics of the waste products of his plant and the general type of the devices used or methods applicable for their removal. He is then in a better position to judge intelligently the importance and necessity of such removal, and plan the best methods or equipment. It is the purpose of this series of articles to enumerate some of the common wastes which occur in the various industries, together with their effect, and to describe briefly the general methods employed for their removal and the standard equipment

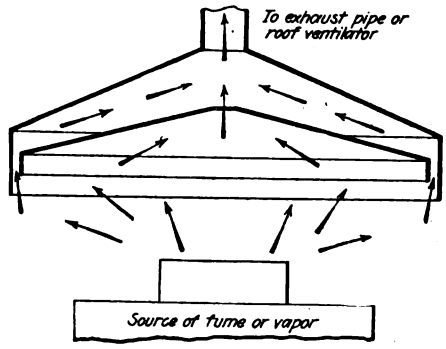
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which may be used for this purpose.

Ordinarily, outside air is satisfactory for ventilation although this is not always true in all industries and locations. Generally, it is only necessary to remove the dust from the outside air, although this is not always sufficient, as will be explained later in this article, which will discuss fume, gas and vapor removal.

Some fumes, gases or vapors may have the appearance of being harmful, although they are only moderately so if carefully collected and disposed of, while others, which are less noticeable and often more dangerous, are entirely overlooked. In some industries where the presence of such objectionable by-products is a serious problem, their disposal is looked after very carefully; in other industries, where this is an incidental problem, it may be overlooked.

Fumes may be pungent, acid, corrosive and poisonous, depending upon the particular chemical or process producing them. Because there are so many different diseases or other serious consequences which may result from inhaling some of these fumes, each plant must study its own problem carefully. The most serious hazards occur in plants manufacturing chemicals or chemical products. During the war, an extensive study was made of the fumes created in the manufacture of explosives, together with the effect on the workers and the methods of safeguarding them.

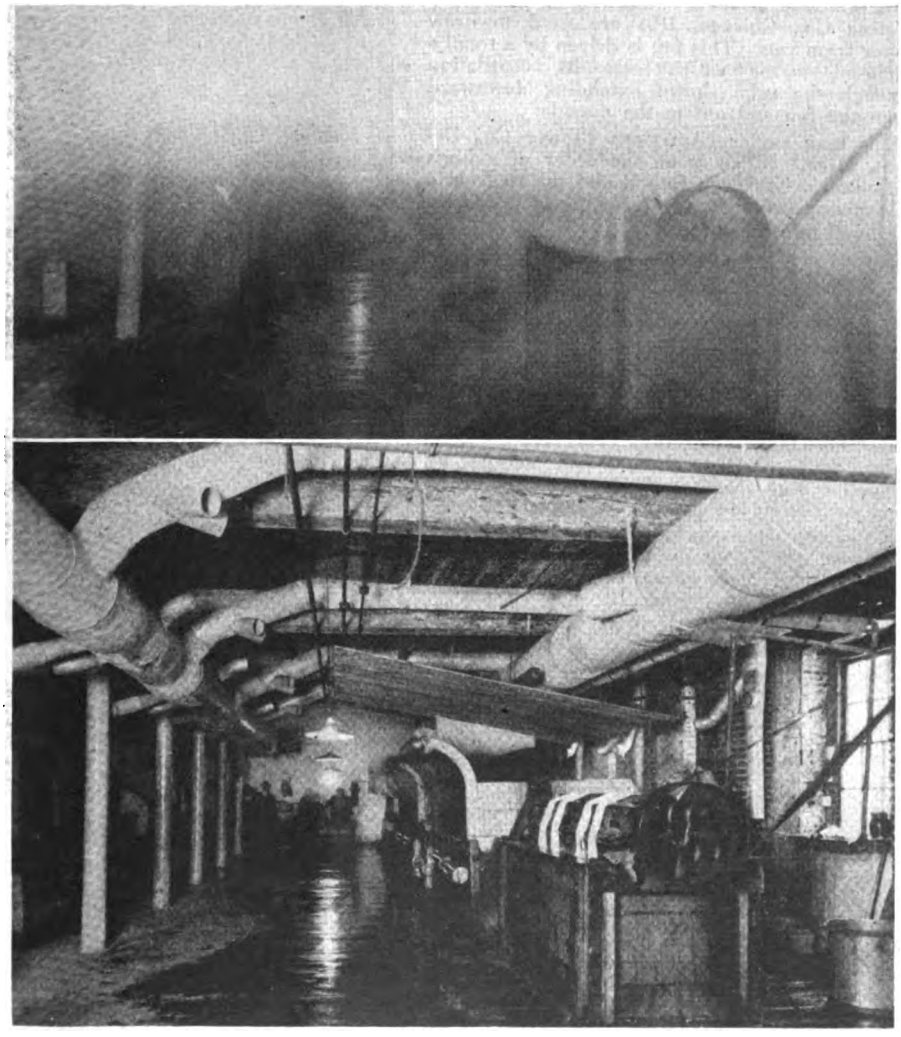


Double hoods, such as this, create a high velocity circulation of air through the narrow slot around the edge of the hood and prevent the escape of fumes ino the room.

Men in this and other chemical industries are generally familiar with the hazards and the methods of overcoming them so that problems incidental to the treatment of the more hazardous gases and fumes will be treated rather lightly in this article. However, the general principles employed in their removal are not different from those used with products less dangerous. The main problem in removing the more dangerous fumes or gases is to exhaust them surely and quickly before they have had an opportunity of escaping and diffusing into the room. Even then workers must wear respirators, hoods or masks for their protection, which, however, does not decrease the necessity of exercising every precaution to remove the dangerous fumes or gases.

The reason for gas or fume hazards in the average plant of any except the chemical industry, lies in the fact that injurious gases or fumes are produced in probably only one or two of the many operations or processes in the whole plant. In other words, such hazards are connected with a minor part of the industry and are outside of the ordinary experiences of the men in the plant. The most common industrial uses of acids which generate fumes, sulphuric, hydrochloric (muriatic), nitric and hydrofluoric acids, are in the pickling of iron or steel before galvanizing, tinning, enameling or applying some other coating or finish. Some of the other industrial processes which give off gases or fumes due to the use of acid, which should be removed, are the manufacture and charging of storage batteries, the manufacture of wood pulp, hats, leather, fertilizer, rubber, candles, glue, vinegar, and numerous other products, as well as in electroplating, etching (both of copper and glass), bleaching, dyeing, cleaning and in producing special finishes on brass, copper and other metals.

Alcohol, particularly wood alcohol, gasoline, naphtha, benzine and benzol fumes are both poisonous and explosives and so must be removed.



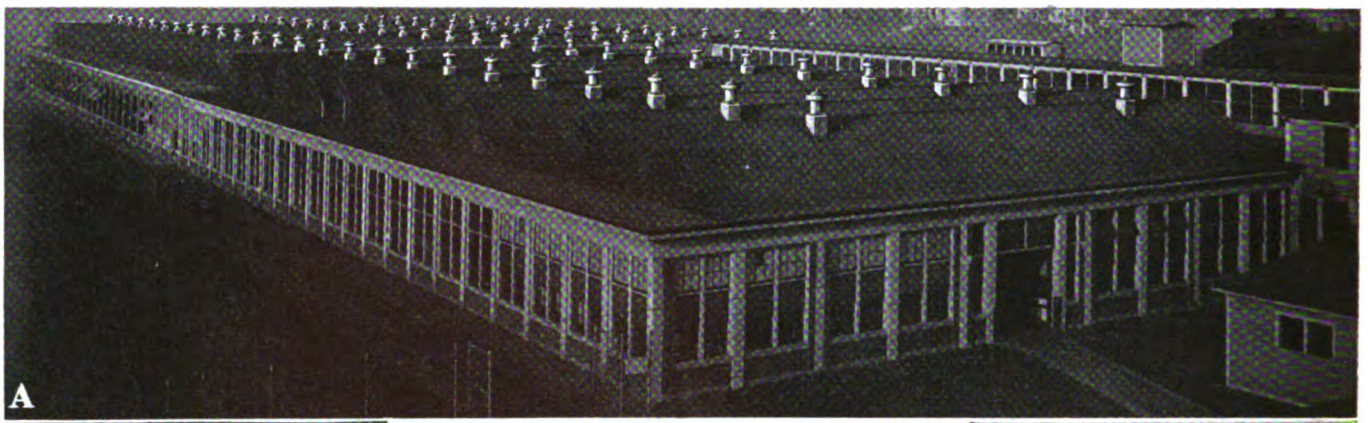
Two views of the same installation which show the effect of using the exhaust system.

In bleaching, dyeing and finishing in textile mills, the steam rising from the process would create such a fog that it would be almost impossible to work, as the hot, moist atmosphere makes workers sluggish. The upper photograph was taken when the exhaust system was not in operation. The lower of the two illustrations shows how conditions changed after the ventilating equipment had been operating exactly three minutes. This installation was made by the American Blower Company, Detroit, Mich., at the Valkone Dye and Finishing Works, Philadelphia, Pa.

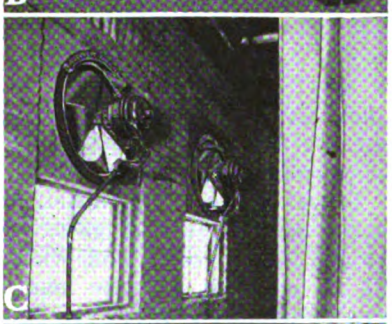
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Types of Equipment for Removing Fumes

Nine Typical Installations in Industrial Plants









A—Here 78, 18-in. roof ventilators (Globe Ventilator Co., Troy, N. Y.) are installed on the machine shop of the Heald Machine Co., Worcester, Mass.

B—Another type of roof ventilator (B. F. Sturtevant Co., Boston, Mass.) is used on this shoe factory. The wind blows into the small end of this ventilator and aspirates the air from the building as it passes through.

C—These propeller fans (Autovent Fan & Blower Co., Chicago, Ill.) placed in the window draw warm, dry air past sheets of sandpaper to speed the drying of the glue.

D—In this case, propeller fans (Ilg Electric Ventilating Co., Chicago, Ill.) are used to draw vapor from vats. This fan is driven by a totally-enclosed motor which gets its ventilation through the tube shown extending downward from the fan and out to the outside.

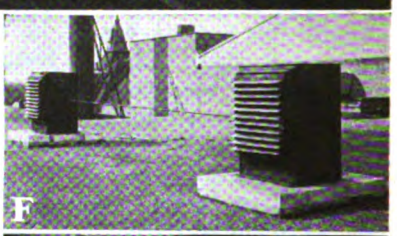
E—This man cooler (American Blower Co., Detroit, Mich.) which is on the order of a huge desk fan, drives heat, fumes, and smoke from a galvanizing furnace away from the men and up the hood into the flue.

F—Instead of depending upon natural ventilation, Ilg propeller fans are placed in pent houses on the roof and draw the vapors out of the building. The shutters on the front automatically close when the fan is not in operation.

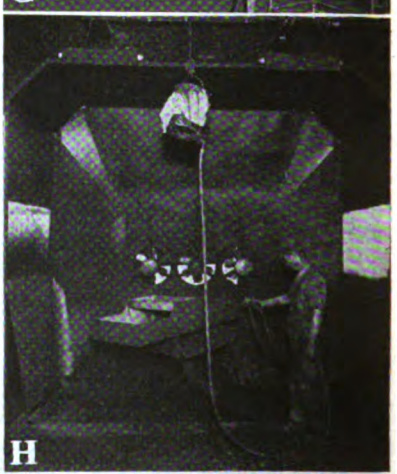
G—An Autovent blower in connection with an exhaust pipe and hoods over each machine is used to remove fumes and heat.

H—In mechanical painting (W. N. Matthews Corp., St. Louis, Mo.) three totally-enclosed Ilg propeller fans are used to draw the paint vapors away from the operator.

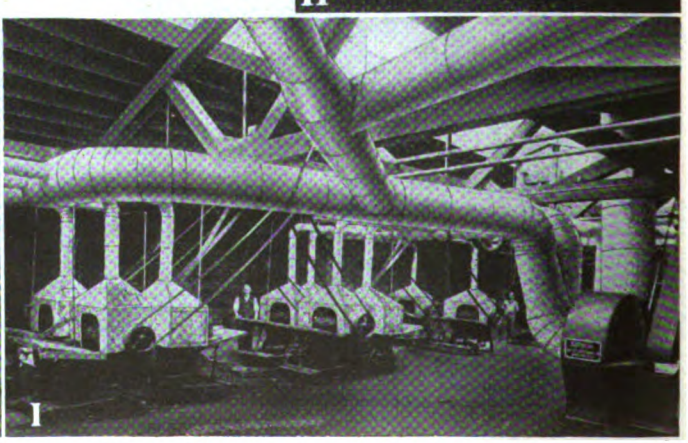
I—In this Sturtevant installation in a hat factory, each machine is closely covered with a hood connected to a main exhaust line which removes the vapors without permitting them to diffuse.



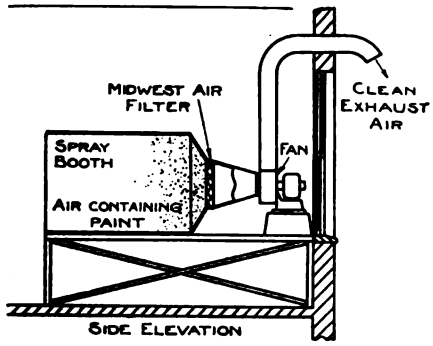






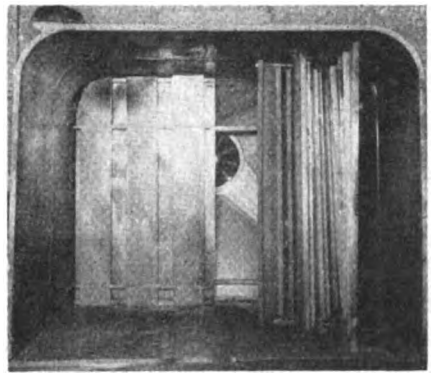


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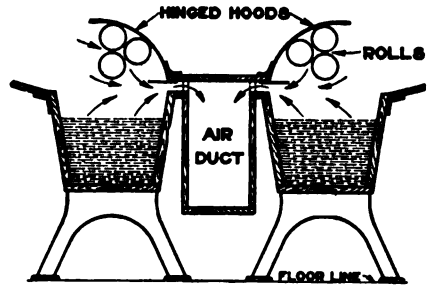
Filtering paint-laden air where a paint gun is used.

In mechanical painting booths the volatilized paint must be drawn away from the operator. To prevent the paint clogging the fan or discharging in the open, one method of removal provides for the insertion of a special air filter at the outlet of the booth and ahead of the exhaust fan, as shown in the accompanying sketch. In this way the paint is removed before it reaches the fan and so does not affect the fan nor contaminate the atmosphere. These filters, one type of which is made by Midwest Air Filters, Inc., New York City, are removed and cleaned by dipping them in a special solvent which removes the paint.



One method of preventing paint vapors from being discharged into the atmosphere.

Where it is not desirable to permit paint fumes generated by the paint gun to be removed through the exhaust system and discharged out into the air, a scheme such as this may be used. Here a special baffle is erected in the back of the paint booth between the painting operation and the exhaust fan. This baffle consists of sheet metal channels so arranged that the direction of the air is changed several times before it gets through to the exhaust fans. As a consequence, the paint is deposited on the baffles. These may be cleaned by putting them in a solvent, although generally a grease, paraffine or some other coating is placed over the baffle. When the baffle is dismantled and placed in hot water this coating is dissolved and carries the paint away with it. This is one method recommended by The DeVilbiss Manufacturing Company, Toledo, Ohio.



Another method of removing steam and vapor before they become diffused in the room.

Here the inlet to the air duct, which is connected to an exhaust fan, is placed so as to draw the incoming air past the operator, over the vat and directly into the duct. This arrangement is used in connection with a sizing machine in a hat factory.

Ammonia fumes are also irritating.

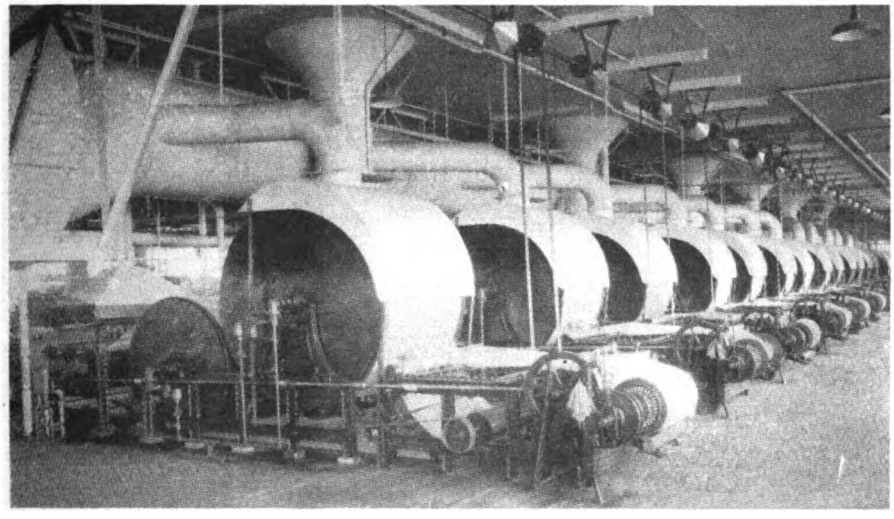
Melting and casting of lead, brass, and some alloys also may cause poisonous fumes. Heat-treating furnaces, particularly if cyanide is used, must also be guarded against. In mechanical painting or the application of other finishing materials by means of an air paint gun, some method of protecting the worker from the lead in the paint, which is frequently carried in a poisonous solvent which is volatilized in the air by the operation. This solvent, in many instances, is also somewhat poisonous, or at least obnoxious.

Some processes create non-poisonous water vapor which needs to be removed. Frequently, however, objectionable fumes are mingled with the water vapor and so make its removal imperative. Water vapor is formed, for example, in paper-machine rooms, foundries, bleacheries, dye-houses and finishing rooms, hat factories, laundries and other places where evaporation takes place from drying material or from an open bath of hot liquid.

An excess of moisture in the atmosphere is objectionable in various ways besides the enervating effect upon those subjected to it. A hot, moist atmosphere, which causes the formation of a fog, seriously interferes with rapid and efficient work on the part of the employes. Also, the condensation which settles upon the ceiling or other overhead structure of the building produces rapid corrosion or deterioration and also causes damage by dripping upon the materials in process of manufacture. This could not be permitted in textile, food products and many other industries where the product would be made valueless, perhaps, by the introduction of foreign material.

Some of the Methods of Removing Fumes, Gases and Vapor

A general rule to be followed in the removal of fumes and vapor is to catch them at their source, insofar as possible, and prevent their becoming diffused throughout the room. Where the quantity of obnoxious gases is small, so as to be well diluted with air, general room ventilation may be sufficient, in many cases, to maintain the necessary degree of purity. Many buildings are provided with skylights and monitor construction which can be opened to permit impure air to escape. A few open windows in the lower part of the building, in warm weather, will admit incoming air and create an upward draft which carries the fumes or vapors up and out. However, it is well to remember that either the monitor windows on both sides be opened or, particularly in winter, only the monitor on the side opposite the wind be opened. Otherwise, the force of the wind will drive in-



Hot, moist air is removed from 18 slashers by a specal hood and exhaust system connecting to a central exhaust pipe.

The hoods fit down closely over the cylinders and prevent the moisture from escaping into the room, where it would condense on the ceiling and perhaps drip on to the product. In case a slasher is shut down, the hood may be closed off by the special damper in the pipe just above the hood. This installation was made by the B. F. Sturtevant Company, Boston, Mass., at the Riverside Cotton Mills, Danville, Vt.

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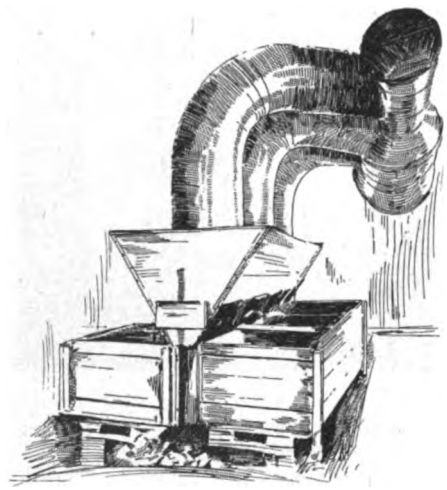
coming air down and so retain the fumes or vapor in the room, instead of removing it. Monitors or skylights are frequently satisfactory in connection with the removal of a certain amount of smoke, fume or light dust arising from the general operations in the industrial plant.

In general, hoods connected with a strong outward draft, should be fitted over the source of the offensive product as closely as practicable without interfering with the working space required for the operative. Sometimes hood and general room ventilation may be combined to good advantage, thus securing better results for a single cost of operation. In handling a fume or gas of any kind, the first point to be ascertained is whether it is lighter or heavier than air. If lighter, the hood and exhaust opening should be located above, so that the gas will naturally rise into it when accelerated by the induced draft.

This may be illustrated by the case of a forge shop where ventilation is best accomplished by placing a hood over each individual forge and connecting it with the trunk line leading to an exhaust fan. This not only catches the smoke and gases as they arise from the fire but also furnishes a certain amount of general or room ventilation when supplemented by an abundant supply of fresh, tempered air to replace that which is constantly drawn off by the hood. Frequently monitor roof construction is also used to draw off any gases which escape the hood, as well as the heat of the forging operation.

The form of hood and velocity of flow both have an important bearing upon the effective removal of gases which are lighter than air. In the case of those gases or fumes which are not especially offensive, or where they are well mixed with air, good results are obtained when the lower edge of the hood is placed about 18 to 20 in. above the point where the gas is produced, providing that the edges of the hood have a good overhang and the air velocity is not less than 200 ft. per min. over the entire bottom of the hood.

It is sometimes necessary in the application of fans for the removal of smoke and fumes, to so design the hood that it will not be in the way of the workman and still be capable of catching the noxious gases before they get into the room. Most failures in such installations are due to the hood being too small. To determine the dimensions for such a hood, it is good practice to make the mouth of the hood extend out over the kettle or furnace at least 6 in. in every direction, when the hood is not elevated over 2 ft. above the surface of the kettle or furnace. For every additional 2 ft. of elevation, the size should be increased 6 in. each way.



Here the fumes are removed before they rise high enough to get to the worker.

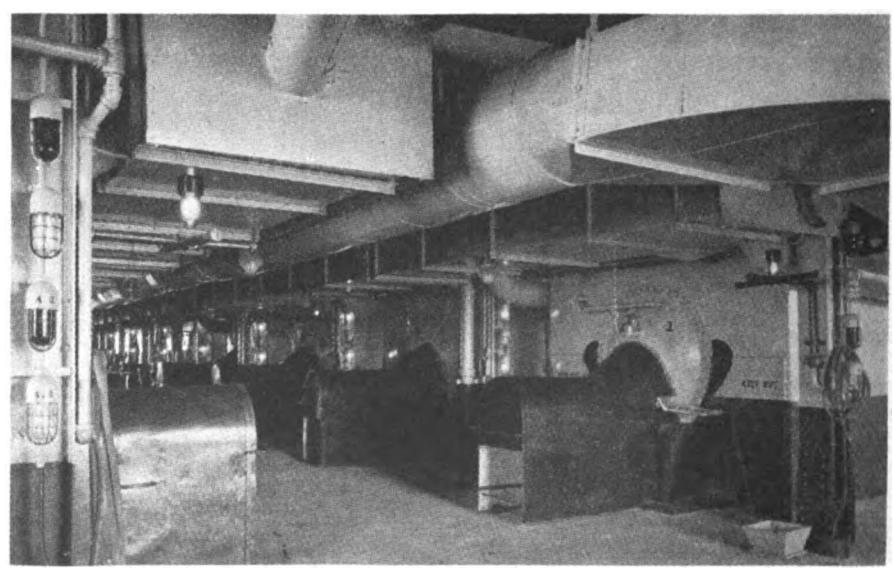
The inlets to the exhaust pipe are placed low, just above the edge of the vat, so that they can draw off all obnoxious fumes or vapors before these diffuse into the room.

Ordinary practice is to make the area of the branch pipe at least 1/16th of the hood area. For instance, a furnace 2 ft. by 4 ft. with the bottom of the hood 4 ft. above it would take a hood 4 ft. by 6 ft. The area of the pipe would be 1/16th of this, or 1½ sq. ft. The branch pipe should, therefore, be approximately 17 in. in diameter, and the velocity at the mouth of the hood under average conditions would be between 100 and 200 ft. per min.

It frequently happens in manufacturing processes that poisonous and noxious gases have to be removed in a more efficient manner. If the plant engineer should attempt to exhaust sufficient air through a hood to create enough suction at the mouth to gather in all the fumes, the size of the pipe and the quantity of air to be handled would frequently be out of all reason. This situation can be very satisfactorily avoided by the use of a double hood with about an inch clearance between the outside and inside sections along the edges. The inside hood is then tapered back and the pipe is so connected that sufficient air is drawn up around the edges through the small area between the inside and outside sections to create a velocity of about 1,000 ft. per min. in this slot and about 75 to 100 ft. per min. over the central area. A high velocity, therefore, exists around the edge of the hood and any gases that do not naturally rise into the central opening are sucked in before they escape into the room. Two of the sketches reproduced with this article show how these double hoods are constructed and installed.

Fumes which are heavier than air, such as those from storage batteries, gasoline, and the gases formed in brass and iron foundries, require a somewhat different treatment. In most cases of this kind, a downward

(*Please turn to page 304*)



Vapor-proof lighting fixtures are necessary features around explosive or inflammable gases.

In this du Pont installation individual hoods are placed over the charging hoppers. A main floor exhaust duct is located in the right foreground, with fresh air supply ducts along the right-hand wall and also in the center bay of the building, near the ceiling.

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Methods of

Taking and Recording Rewinding Data

On D.C. Armatures so That the Details of the Winding Can Be Readily Understood and the Job Handled Properly by Any Winder

By A. C. ROE

Renewal Parts Engineering Department, Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.

HOW OFTEN DOES it happen that, after an armature has been stripped, it is found that someone has forgotten to notice or record some important detail of the rewinding data? Mistakes of this kind are often costly. In this article Mr. Roe describes several systems for taking down the complete data in such a manner that any winder can readily understand and use it and which will insure that all of the important data are recorded.

WHEN repairing direct-current armatures, particularly when it is necessary to remove the old winding and rewind the armature with new coils, it is essential that the winding data be recorded in a manner that is easily understood by other winders in the shop. By winding data, we refer to such connection information as lead pitch, lead throw, coil pitch, and the like. There are several rules and methods for taking data; also, each type of winding has its own peculiarities. Therefore, this article will be confined to describing the various types of connections and the methods of taking and checking the rewinding data necessary for them.

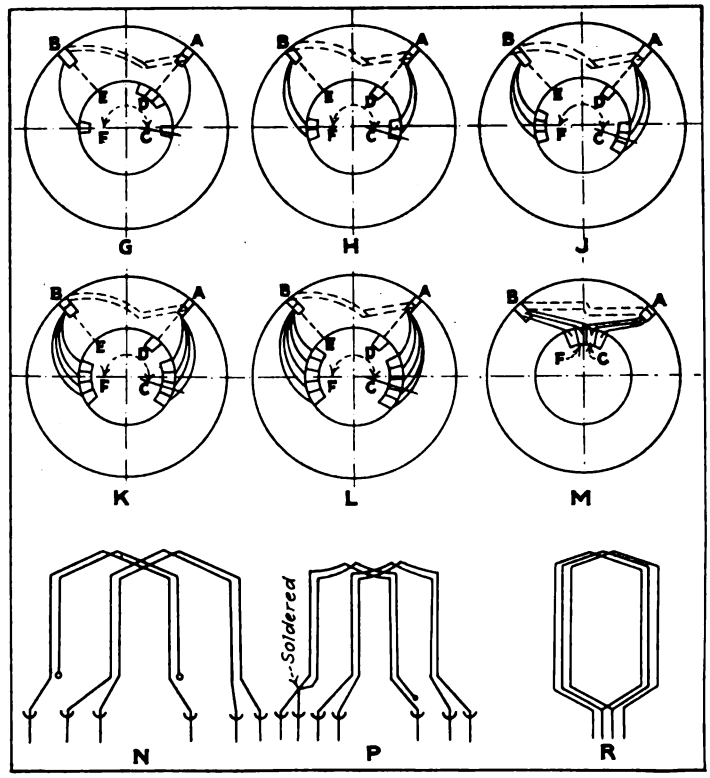
The first step is to develop a system of recording the data that are required in the armature winding room. This usually consists of a card filing system or blank notebook in which each winder puts his notes. In some shops, a blank form has been developed which standardizes the method of taking and listing the data. In any system that may be used for recording this information, the following are the items that should be listed in order to insure that sufficient information has been taken to rewind the armature in the correct manner:

(1) Order number to which all time and material are to be charged.
(2) Customer's name or department to which the armature belongs.
(3) Nameplate rating of the motor, that is, the horsepower, voltage, speed, number of poles, type, frame number, and any other identifying marks that may be on the nameplate.
(4) Number of slots in the armature.
(5) Total number of bars.
(6) Turns per coil.
(7) Size of wire.
(8) Number of wires in parallel per coil, or the number of wires per commutator bar.
(9) Pitch of coil.
(10) Number and size of bands; that is, the width and location of the band. Size of banding wire.
(11) Style number of armature.
(12) Serial number of armature.
(13) Distance that the end winding projects beyond the core, and in some cases, the distance between the bottom of the winding and the shaft.

Figs. 1 and 2—Here is a very comprehensive method of taking armature data.

The data are recorded on cards made up in a manner similar to that shown in Fig. 1. Reference is made to sketches shown in Fig. 2 for specific dimensions, depending upon the type of winding that is used. Fig. 2 may be printed on the back of Fig. 1, or each winder may be provided with a chart similar to Fig. 2. Details regarding the use of each sketch in Fig. 2 are given in the text of this article.

MOTOR Type K R Frame 16
H.P. 100
SERIAL NO. 43984
VOLTS 600
NO. ARMATURE SLOTS 31
NO. COMMUTATOR BARS 155
REFER TO FIGURE L
THROW OF COILS, A-B 1-10
THROW OF LEADS: RIGHT, C-D 1-24; LEFT, E-F 1-30; TOTAL, C-F 1-91
REMARKS 5 bands - 2 on core - one 2" each end
Left-hand coils end room = 4 7/8"



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(14) Distance from the front of the commutator bars to the end of the shaft or oil thrower, or any other fixed point that will insure the commutator being pressed to the right distance on the shaft.

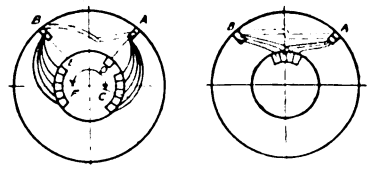
Item 13 is very important because in a large number of the older types of motors, the end housing has ribs on the bearing housing which project into the frame along the shaft and if the winding drops down or projects too far, it will rub. A winding that is otherwise good may thus be ruined.

Item 14 is important when the commutator has to be removed from the shaft for repairs, particularly so if the field frame is not in the shop and it is desired to press the commutator to the correct position on the shaft so that it will not interfere with other parts of the motor.

We will now consider a number of different forms that have been used for recording the data that we have just described. A simple form that may be used for both lap and wave windings is shown in Fig. 3. In this form, space is provided for recording the nameplate data as well as the number of slots and number of commutator bars. At the top of the form are two sketches: The one at the left is for use with wave windings and the one at the right is for use with lap windings. On these sketches, the dimension *AB* is the coil pitch and is recorded in the proper space on the form. In determining the coil pitch, *AB*, *A* is the slot in which the bottom conductor lies, and *B* is the slot in which the top conductor of this same coil lies. For wave windings, the following lead throws are also recorded: *EF*, which is the top lead throw; *CD*, which is the bottom lead throw; and *CF*, which is the total throw of the leads, or the lead pitch. In using the wave winding sketch, that is the diagram at the left, for windings having three or five coils per cell, the middle coil should be used for laying off and taking the data.

A more comprehensive method of taking the data than the method just given is by the use of the forms shown in Figs. 1 and 2. Cards or blank pages may be printed in a manner similar to Fig. 1, or a rubber stamp may be made up similar to Fig. 1, and stamped on any suitable sheet of note paper. Each winder would then be provided with a blank similar to Fig. 1, and one chart similar to Fig. 2, or this chart may be stamped or printed on the back of the data sheet. Then, in recording the data, the winder would fill in the seventh line of Fig. 1 with the proper reference to the particular diagram in Fig. 2 that was used.

When taking data on a wave winding that has the same number of



K.W.
H.P. .....
Serial No. .....
Volts .....
No. Armature Slots .....
No. Commutator Bars .....
Refer to Figure .....
Throw of Coils, A-B .....
Throw of Leads { Left, E-F ..... Total, C-F ..... Right, C-D .....
Remarks .....

Fig. 3—This simple form may be used for both lap and wave windings.

The coil throw and lead throw are measured as indicated by the diagrams at the top of the form. The diagram at the left is for wave windings, while that at the right is for lap windings.

slots and commutator bars, reference would be made to *G* of Fig. 2, in the seventh line of the form shown in Fig. 1. If the wave winding has twice as many commutator bars as slots, reference would be made to *H* of Fig. 2. If the wave winding has a dead coil, reference should be made to both *H* and *N* of Fig. 2; for example, a winding having 49 coils and 97 bars. If the armature has a wave winding using 47 slots and 94 bars, and was intended for use with a four-pole machine, thereby giving a half-idle bar, *H* and *P* would be the diagrams referred to. Diagram *J* of Fig. 2 is used for windings having three coils per cell, while diagram *K* is used for windings having four coils per cell and diagram *L* for windings having five coils per cell. Diagrams *M* and *R* are for use with lap windings.

In the foregoing several simple methods for recording the rewinding data have been described. It will be found that the needs of many small repair shops for an adequate system of taking off winding data will be amply filled by the forms that have just been described, while the conditions encountered in large shops handling a great variety of motors will be met by the use of the system that will be described in what follows. This system is such that it will accommodate special windings and windings which have unusual features that cannot be easily described in the forms that have just been presented.

This system consists of the data sheet shown in Fig. 4, and the chart in Fig. 5. For convenience in filing and keeping the data so that they can be readily located at some future date, the forms shown in Figs. 6 and 7 may be added.

The data sheet, shown in Fig. 4, will cover practically every case met with except that of special cross-connected armatures, having taps to slip rings. This form can be made up on a rubber stamp about 4 in. by 6 in. in size, and stamped on the pages of an ordinary notebook. It is better, however, to furnish each winder with a number of 4-in. by 6-in. printed cards similar to the one shown in Fig. 4. The winders record the data for each job on these cards and then turn them over to the foreman, who places them in a card file. While the jobs are in process, the cards are filed under the customer's name. After the job is completed, the cards are placed in another file and arranged according to the name of the manufacturer of the armature that was repaired; that is, Westinghouse, General Electric, Century and so forth. As the group of cards under each manufacturer's name becomes larger, the cards can be subdivided into groups according to horsepower, and, later, as the number of cards becomes still larger, each group under one horsepower classification can be subdivided into smaller groups classified according to speed and voltage. This is a valuable record for any shop to have. Often an armature is received for repairing and there is some doubt as to the way it should be rewound. If a check is made in the card file on the same type of armature it will often be found that the job received has the wrong size of wire or that some important detail is not standard.

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The top line of the form shown in Fig. 4 provides a space for the order number and the customer's name. On the next line are recorded the horsepower, voltage, speed, and full-load, ampere rating of the motor. The third line provides a space for the name of the manufacturer of the motor and the type and frame size. The number of bars and slots and also the number of wires per bar (W-B) are recorded on the fourth line. The term "wires per bar" means the number of active leads from the coils that connect to one commutator bar and does not include any dummies or fillers. This is a check upon the number of wires used in winding the coil. For instance, let us assume that we are winding an armature having 71 bars and slots and four wires per bar, using three turns of No. 11 double-cotton-covered wire. Since one-half of the number of wires per commutator bar equals the number of wires in parallel per single coil, the coils for this armature would be wound with three turns of two No. 11 double-cotton-covered wires in parallel. Let us take another case of an armature having 55 slots, 165 commutator bars, four wires per commutator bar, and using two turns of No. 10 double-cotton-covered wire. In this case we have three times as many commutator bars as slots and consequently each winding unit or complete coil will consist of three single coils, each single coil being wound with two turns of two No. 10 double-cotton-covered wires. Each winding unit or complete coil will have twelve leads; that is, six top leads and six bottom leads.

Recording the data by using the number of wires per commutator bar, the number of turns per coil, and the size and kind of wire is a better check than putting the coil data down as two turns of six No. 10 wires, or in some cases, three turns of two No. 15 wires. In the latter case, there is a chance of reading this information as three turns of four No. 15 wires when there are twice as many bars as slots.

On the fifth line are recorded the turns per coil, and the size and kind of wire used; that is, No. 10 square d.c.c., and so forth. Any marking or numbers appearing on the shaft are put down on the sixth line.

The banding information is recorded on the seventh line. This is very important and should include not only the size of banding wire used but also the location and overall size of the band. The width of the end band should be noted and in the case of high-speed machines special attention should be paid to the kind of banding wire that is used. The spacing of each wire in the various bands should be noted and in the case of wide bands it should be determined whether they

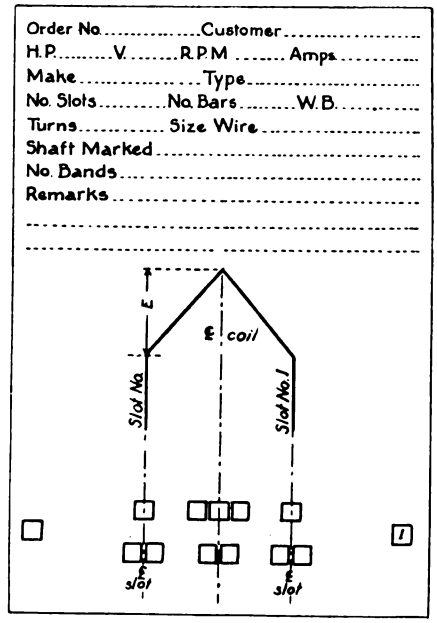


Fig. 4—Here is a data sheet that is very flexible and will fit practically every case encountered, except that of special cross-connected armatures having taps to slip rings.

In using this form, the slots holding the top and bottom coil sides of one coil should first be located. Call the slot holding one coil side, slot *1*, and count from this slot as a base to obtain the number of the slot holding the other coil side. The commutator bars to which the leads of this coil are connected should be located next. These bars are indicated at the extreme right and left of the diagram. Finally it is necessary to locate what part of the commutator lines up with slot *1*. If slot *1* lines up with the center of a commutator bar, we would use the top row of bars shown in the diagram, and number it, counting from bar *1*. If slot *1* lined up with the mica between two bars, we would use the bottom row of bars shown in the sketch and number the bars on each side of the mica according to the distance from bar *1*.

are split into sections by the use of insulating material. In some cases it will be found that the core bands have a strip of tin of a width equal to the band, and which extends around the armature under the band. This is found principally on railway armatures. Using tin under a core band in place of insulation such as fullerboard or fibre will insure a tight band. Insulating material will dry out in time and the band will work loose, whereas with the tin strip, the banding wire is soldered directly to the tin thereby making a permanently tight band.

The last three lines of the form provide room for recording any other data that seems necessary regarding the winding. The dimension indicated at *E* of the sketch below the data is for recording the distance that the coil ends project beyond the coil.

In using the form shown in Fig. 4, the following procedure will be found very convenient for recording the data:

(1) Fill in data on upper part of card.
(2) Count number of slots and bars.
(3) Check for dead coil, half-idle bar, etc., and enter details under remarks.
(4) Locate the slot in which any top coil lead falls and call it slot *1*.
(5) Mark teeth on each side of this slot.
(6) Mark the commutator bar to which the lead selected connects and call it bar *1*.
(7) Check end room, and enter at *E* of sketch.
(8) Lift coils and locate slot in which falls the bottom coil side of the coil selected in (4). Using slot *1* as a base determine slot number for this coil side and record on sketch.
(9) Light out bottom lead. Using bar *1* as a base, determine number of commutator bar to which this lead connects.
(10) Mark slot holding bottom coil side of the coil selected at (4) and also mark the commutator bar to which the bottom coil side connects.
(11) Determine bottom lead throw.
(12) Count lead pitch.
(13) Count coil pitch.

In Fig. 5 are 13 different applications of the data sketch shown at the bottom of the form in Fig. 4. The layouts shown at *I, II, III, IV, V, VI, VII, VIII,* and *IX* are for wave windings. Those shown at *X, XI, XII,* and *XIII* are for lap windings. In *I*, Fig. 5, is shown the sketch for an armature having the same number of bars and slots and in which the brushes fall on the center line of the poles. As can be seen, the center line of slot *A* falls on the center line of bar *D*. Inasmuch as the coils per cell will equal the total number of bars divided by the total number of slots, in this case there will be only one coil per cell.

In *II* of Fig. 5, is shown a developed sketch for an armature having twice as many bars as slots and which also has a dead coil. Since there are twice as many commutator bars as slots there will be two coils per cell. In any winding having a dead coil and more than one coil per cell, the idle coil should be the first single coil on the right, as shown in *II* of Fig. 5. The dead coil should

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be in the first complete coil or winding unit that is put in the armature. In the sketch shown at *II*, the center line of slot *A* falls on the mica to the left of bar *D*. This is an important part of the winding data and should be recorded as shown in the sketch. In *III* of Fig. 5 is shown the developed sketch for an armature having three coils per cell, all coils of which are active. In this case it will be seen that the center line of slot *A* falls on the center line of bar *D*.

The sketch shown at *IV* is for an armature having four coils per cell including one dead coil. The sketch shown at *V* has five coils per cell.

The sketches shown at *VI* and *IX* of Fig. 5 show two methods of recording the data for an armature having a half-idle bar; that is, for an armature having one bar too many. This type of winding is used on a number of the old machines in which the same armature or commutator was used for a lap as well as for a wave winding. As a lap winding generally has an even number of bars and a four-pole wave winding requires an odd number of bars, it follows that when an armature having an even number of bars is used for a wave winding, there will be one bar too many. For example, if an armature having 49 slots and 98 bars is used for a wave winding, it will be necessary to jump two bars together so as to make the equivalent of 97 bars, which would be required for this type of winding. In diagram *VI* this is accomplished by soldering the two top leads together at a convenient point and bringing two leads out from the junction to the two commutator bars as shown. The bottom lead of the right-hand single coil is dead-ended; that is, it is cut off and insulated from the adjacent bottom lead. The soldering together of the top leads forms a short jumper between bar *F* and the adjacent bar to the right. In connecting the armature, care should be taken that a bottom lead is not connected to the bar marked with a cross. The best way to avoid the possibility of this happening is to lay off the distance *CD* and *CF* when putting on the first coil and then fill the bar next to the right of bar *F* with dummies, or short pieces of wire of the same size as used in the coils.

Diagram *IX* of Fig. 5 shows the long-jumper method of laying off a half-idle bar connection. With this method the bottom lead of the right-hand single coil is soldered to the bottom lead of the second single coil. One lead from this junction is brought out to bar *C*, as is shown in the diagram. The two top leads are brought out to two bars, as shown at the left of diagram *IX*. The same precaution should be taken in laying down the bottom leads as was mentioned for the short-jumper type of

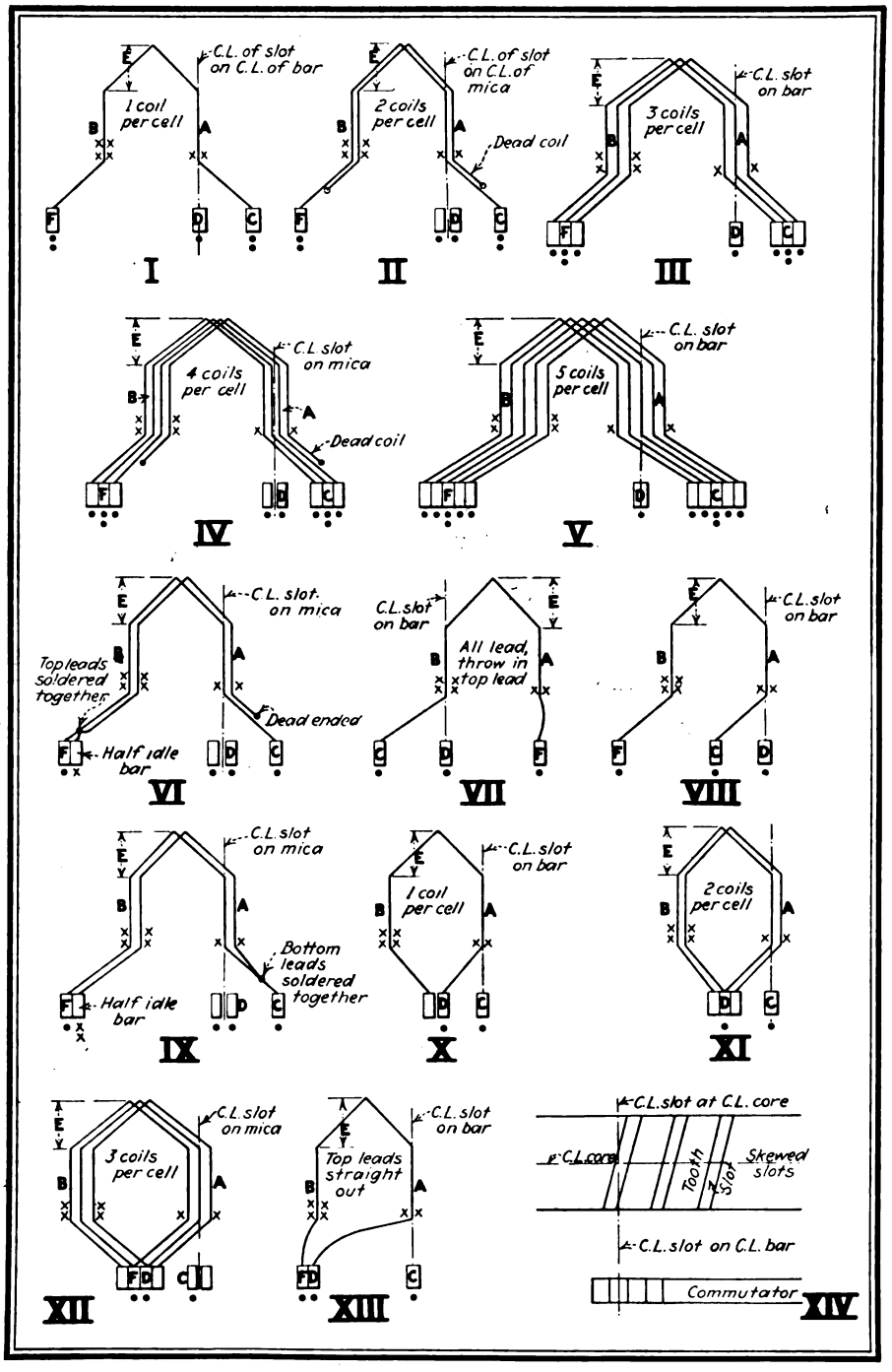


Fig. 5—These diagrams illustrate the method of recording data for lap- and wave-wound armatures.

In all of these diagrams, the teeth on each side of the slot are marked with crosses. For instance, in diagram *I*, slot *A* falls between the crosses on each side of a coil side. Likewise, in diagram *II*, the crosses indicate the teeth on each side of a slot. Thus it is easy to see that in diagram *II* there are two coils per cell instead of two slots having one coil per cell. The slot holding a bottom coil side for any particular coil is marked with one cross on each tooth, as shown at slot *A* in any of the above diagrams. A slot holding the top coil side of any particular coil is marked with two crosses on each tooth adjacent to the slot, as shown at slot *B* in any of the diagrams. The dots placed beneath certain commutator bars in each of the diagrams represent center punch marks on the bars. These are used to distinguish the bars that are connected to the winding unit or coil that lies in the slots marked with the crosses. If there is more than one coil per cell, two punch marks are used to indicate the particular bars belonging to one coil. This is preferably the center coil of the group, as shown at *III*, *IV*, and *V*. In each case in the diagrams, *AB* represents the coil pitch and is measured in slots; *CD* represents the lead throw and is counted off in commutator slots; *CF* represents the total throw of the leads; that is, the lead pitch, and is measured in commutator slots. Diagrams *I*, *II*, *III*, *IV*, *V*, *VI*, *VII*, *VIII* and *IX* are for wave windings, while diagrams *X*, *XI*, *XII*, and *XIII* are for lap windings.

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connection, described in the preceding paragraph.

Digram *VII* of Fig. 5 is for a wave winding in which the brushes are on the center line of the neutral region. The bottom leads are connected straight out, as shown, between slot *A* and commutator bar *F* in diagram *VII*. Hence, all the throw is in the top lead. The top slot is, therefore, used to locate the lead throw *CD*.

At this point, it might be well to draw the distinction between "lead throw" and "lead pitch." Lead pitch refers to the total distance, measured in commutator bars, between the top and bottom leads of any one single coil, as *CF* in *I* of Fig. 5. On the other hand, lead throw refers to the distance between a commutator bar which is in line with a slot containing a coil, and the bar to which one of the leads in the slot mentioned connects, as *CD* of *I* in Fig. 5. Consequently, in a wave winding with the brushes on the center line of the poles, there is only one lead pitch, but there are two lead throws: a bottom lead throw and a top lead throw. In some cases, the two lead throws are alike, while in other cases they are unequal.

Diagram *VIII* of Fig. 5 shows a layout for a wave winding that has the brushes on the center lines of the poles, and in which the arrangement of the winding is such as to prevent the bottom leads from having a right-hand throw. This would be the case in an involute winding, such as used in some of the early types of armatures made by the General Electric Company and the Otis Elevator Company. The bottom lead forms part of the coil and is brought over to the left and out at the center of the coil and connected to bar *C*. Notice that with this arrangement, the throw *CD* has been inverted, so as to preserve the meaning of *CF*, which is the lead pitch.

Diagram *X* of Fig. 5 shows the layout for a lap winding having one coil per cell, while diagram *XI* shows the layout for a similar winding having two coils per cell. Diagram *XII* shows a lap winding having three coils per cell.

Diagram *XIII* shows how the data are recorded for a lap winding with the brushes on the center line of the neutral region. The bottom slot *A* is used to locate the lead. This is more accurate than saying that the top leads are connected straight out, or connected 1-and-2, etc., as in most cases a fractional coil pitch is used. This means that the lead must have a slight throw and the method given in diagrams *X*, *XI*, *XII* and *XIII* will show this.

Diagram *XIV* of Fig. 5 shows the method used to line out from a slot to the commutator for armatures having skewed slots. Notice that the line starts at the center line of the slot at the center of the coil. In other words, don't line out from the commutator end of the core, but in every case drop back to the center of the core and to the center line of the slot.

S.O. ..... Customer .....
Hp. ... Volts ..... R.P.M. ..... Amp. .....
Make ..... Type ..... Frame .....
No. of slots ..... No. of bars .... W-B .....
AB ..... CD ..... CF ..... Fig. .....
Size wire ..... Turns per coil .....
Shaft marked .....
Size of band wire ..... No. of bands .....
Remarks .....
.....
.....

Fig. 6—This card may be used instead of the one shown in Fig. 4.

The winder is provided with a chart similar to Fig. 5, and from this chart he selects the diagram similar to the winding on which he is taking data. The reference number of this diagram is recorded on the card in the space marked "Fig."

Fig. 6 shows a card developed for use with Fig. 4. This card provides for the same information as shown in Fig. 4, but in the fifth line the letters *AB*, *CD* and *CF* appear. These correspond to the letters shown in diagrams *I* to *XIII* of Fig. 5. The procedure followed is as given herewith:

Each winder is supplied with a chart similar to Fig. 5. In filling out the card, the winder first fills in the coil pitch *AB*. Then the lead throw *CD* is counted off on the commutator and recorded on the card. The lead pitch *CF* is next counted off and the reference figure (shown on Fig 5) that applies to this winding is then recorded on the card. After recording all the data, the card is turned in to the foreman and a card similar to the one shown in Fig. 7 is filled out. These cards are 8 by 10 in. in size. They are filed according to the manufacturer of the motor. In each manufacturer's section of the file the cards are again subdivided according to horsepower.

A card system is a great deal better than the notebook method of filing winding data, for after a number of notebooks have been filled with data it becomes quite a job to locate the data on an old repair order. For example, suppose we have a 10-hp. standard make of motor in the shop for repairs. The winding data that were taken do not seem to be correct and it is thought best to check with a previous repair job. With the notebook method of recording data, we would have to guess at the date at which we think a similar job was done and then pick up the book that we guess was used about that time. We then thumb through the pages until the required data are located. With the card system we would go directly to the section covering motors made by the manufacturer of the motor in question. In this manufacturer's section, we would then look for the card referring to motors of a certain horsepower and the desired data would be quickly found.

In the foregoing article we have discussed a simple method for recording armature winding data, a more comprehensive method of taking down these data, and a still more complete system for recording these data. The next article of this series will take up other methods used for tabulating winding data and will go into detail regarding methods that may be used for recording the data on special types of windings.

Fig. 7—For convenience in filing, the data taken on a number of the cards shown in Fig. 6 are consolidated on this card.

Type	Hp	Frame No.	Make	Style No.	Serial No.	No. of slots	No. of bars	Coil pitch A B	Lead pitch C F	Lead throw C D	Fig No.	Turns per coil	Size wire	Wires per bar
S	5	5	WH	35021	294641	49	97	1-12	1-50	1-16	II	4	#11	2
M	5	30-40	WH	8709	12469	71	142	1-17	1-72	1-21	VIII	1	½"x⅛"	2
K	5	10	WH	27069	134698	35	69	1-9	1-36	1-11	II	3	#13	4

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, June, 1925

A Way to Get Recognition for Things You Do

IN THESE days initiative and originality, unselfishly applied, are the marks that distinguish the brand of ability that elevates to positions of authority and responsibility from the ordinary variety. Most companies watch for these signs among employes and have a way of finding larger and still larger places for the full growth and development of these evidences of future leadership in their organization.

Engineering societies have for years provided ways to extend recognition for worthy services and developopment work for the professions they represent. The American Institute of Electrical Engineers has its Edison medal, John Fritz medal, and Lamme medal. The American Society of Mechanical Engineers has its A. S. M. E. medal, the Holly medal and the Melville medal. The National Electric Light Association has its Coffin medal, and the Doherty medal and there are many other medals, prizes and scholarships, for the most part awarded to honor appropriately those who have accomplished a meritorious achievement in the arts and sciences.

Now comes announcement of four James H. McGraw medals for electrical men in three branches of electrical work: namely, the manufacturing branch, the jobbing branch and the contractor-dealer branch. These awards have three objectives:

(1) To give public recognition and reward for ideas which have been contributed to the common good by individuals in the electrical industry. (2) To give publicity to these ideas, that they may have wider application and employment. (3) To stimulate and encourage electrical men to think constructively for the broad improvement of the electrical industry and to carry through the ideas that occur to them.

To the electrical industry on the basis of its commercial subdivisions, this is the most extensive recognition of individual enterprise and achievement that has heretofore been set up and opened to men in all departments of the branches specified. Besides this, it sets up an annual test by which the thinking and accomplishment of today can be measured with that of yesterday in commercial progress on the same high plane of excellence of service to industry in any of its branches or as a whole as heretofore extended to engineers and scientists.

Through these awards we believe many discoveries of human intellects developed far beyond our expectations will be found year by year and their work brought forth to mark them as men devoted to a purpose and determined to elevate the electrical industry from a commercial standpoint to the high rank that it justly merits as a public service.

By these medals shall electrical men in commercial work be known. We hope that our readers who are eligible to compete for these awards will grasp this opportunity to gain recognition for the ability that in them lies.

Is the Slow-Speed Motor Coming Back?

THERE has been a definite trend toward the use of high-speed, induction motors for the roll drives in steel mills and other applications requiring a low speed. This has been brought about by the development of unusually efficient gears having a long life, and because the high-speed induction motor is much more efficient and has a better power factor than the low-speed induction motor.

Through the improvements made to the starting winding of the synchronous motor and also due to the use of improved magnetic clutches and other devices, the synchronous motor of today is able to develop much higher starting and pull-in torques than formerly. This has resulted in the application of synchronous motors to slow-speed drives on which it has been considered impossible to use such motors. In fact, one manufacturer is openly advocating the application of synchronous motors to certain steel mill, main roll drives. Steel mill, main roll drives are notorious for the starting torque required.

In deciding between the two types of drives certain factors must be considered such as over-all efficiency, maximum demand, power factor, ease of control, reliability, and relative cost.

What is going to be the outcome? Are we going to see a reversal in tendency from the use of high-speed induction motor units to the use of slow-speed, synchronous motors direct connected to the slow-speed machine? INDUSTRIAL ENGINEER would like to get the opinions of users and manufacturers on this question.

How Often Do You Have Your Meters Overhauled?

ONE of our readers who has had many years of experience in repairing and testing all kinds of electrical measuring instruments, recently made the following statement: "It is not unusual to find watt-hour meters which have been in constant use for several years in industrial plants and in all of that time they have received no attention whatever. If the users only knew what some of these neglected instruments may be costing them, they would realize that money spent for overhauling and calibration of their meters is well invested."

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Recording instruments, and indicating instruments as well, go about their work quietly and perhaps it is only natural to assume, without thinking very much about it, that as long as the moving element rotates, or the needle indicates so many volts or amperes, everything is all right. Nevertheless, the fact is sometimes overlooked that the amount of power acting on the moving parts of meters is small and that any increase in the friction is certain to result in slowing the meter down. The oil in the bearings usually begins to deteriorate after a few months of service, so that its usefulness as a lubricant slowly decreases. Besides this, various other conditions, which are largely the result of natural wear and tear, tend to decrease the accuracy of a meter.

The watt-hour meter has been called the cash register of the electrical system and this comparison is an apt one. The sole purpose of this instrument is to measure a commodity which is produced, sold and paid for just like any other commodity. If it does not perform its functions properly, errors which may be costly when figured in dollars and cents, are very likely to result, although they may not be detected at once.

Failure to have these and other electrical measuring instruments overhauled and checked up at reasonably frequent intervals is an example of the kind of economy that carefully hoards pennies in one pocket and allows dollars to run out of a hole in some other pocket.

Don't Let Personal Feelings Handicap You

IN RECOUNTING some of his experiences, an engineer who has long been engaged in industrial plant work expressed some interesting opinions on the type of executives in a certain plant. Referring to a change which he had proposed in the building layout he said:

"This job came up a good many years ago and was an example of the laboriousness with which some folks will go around a post or column as though it were one of the pyramids. At the time, that job and a number of others aroused a bit of feeling which has only within recent years subsided to the extent of putting the principals on speaking terms. So long as I made a slight improvement here and there, my work was commendable enough. But when I proposed a major operation, such as changing the layout sponsored by someone in authority, then I was treated as though I were trying to take from religion its most helpful tenet. The change was eventually made, but only after persistent argument—and I had to handle the problem like a Richelieu."

This may well have been an extreme case of a certain attitude of mind which the necessity for doing things in the most efficient manner, in order to meet competition, has forced into the background. Nevertheless, most of us are inclined to feel that the ideas and schemes which we have worked out have much to recommend them, and we do not like to see them discarded or materially altered by someone else. Within limits this is a perfectly justifiable and proper way to feel about the work which we have done. If one does not have faith in his ideas and the work he is doing he will not go very far. For this reason it requires an unbiased mind, breadth of vision, and sometimes a good deal of moral courage to admit that someone else can, or has, improved on our work.

Before you give an adverse decision the next time you are called upon to approve plans which involve changes in some method, process, or whatnot, which you have worked out, ask yourself whether your decision is based on personal feelings or on sound engineering principles.

In business, engineering work, or any worth-while field of endeavor, there is no room for personal feelings or dislikes. Every proposition should be considered strictly on its merits. Anyone who attempts to handle a job on any other basis is putting himself under a heavy handicap and thereby seriously lessening his chances of real success.

Avoid Difficulties Instead of Overcoming Them

THE maintenance engineer is confronted continually with difficulties. Interruptions to operation in the path of power service, which may be due to breakdowns, or to any one of the multitude of causes which are responsible for service below par, are faced in his everyday work. His success or failure and the extent to which he keeps out of "hot water" depend upon how he meets these difficulties.

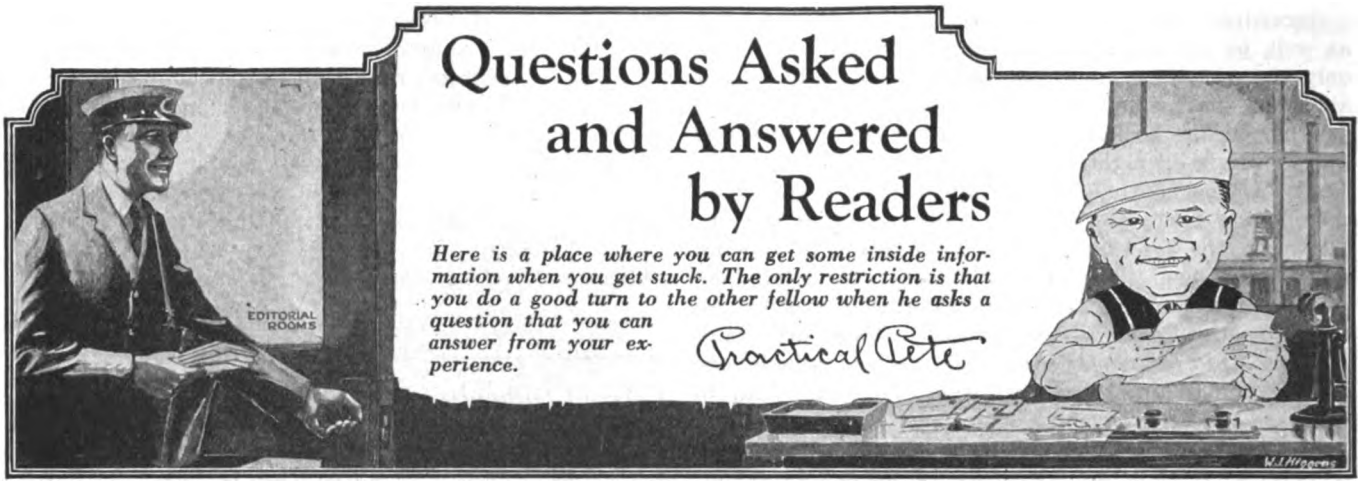
Some industrial men responsible for maintenance work have those under them handle each job as they come to it; these workers adjust a spring, tighten a bolt or belt, replace a worn or defective part or patch it up and rush on to answer another waiting call for help. In other words, they are handy men with their job always two or more jumps ahead of them. Such men solve each problem as it comes up, instead of trying to ascertain some of the whys and wherefores and prevent these problems from arising.

In impressive contrast is the work of a maintenance engineer's department which is largely free from this hustle and bustle. Of course, the unexpected happens and breakdowns or other interruptions of service do occur, but they are the exception rather than the rule. When the unexpected does happen, men who are able to diagnose the trouble and prescribe the most effective remedy are immediately dispatched to handle the job, because their ordinary work is not of an emergency character and they can leave it.

In such cases the question immediately arises, "How does the man responsible for maintenance work manage to keep everything going so smoothly?" The answer invariably is that he has studied his job; he knows what is the cause of each type of trouble and about how often it occurs. This knowledge has shown him where to direct attention before the trouble happens, and at the time when there will be the least interference with operation. His men, instead of spending their time rushing to clear up trouble that has happened, look for places where trouble inevitably will happen, and find the majority of them in advance. They can then choose the time most suitable for themselves and the production department, for making repairs.

How are these prospective difficulties located in advance? The methods vary in different plants but, in general, these involve regular and systematic inspections and overhauling by competent and experienced men who can recognize trouble when it is brewing and know what to do. This inspection routine is practically always backed up with records and reports which are analyzed frequently and made use of regularly. Practically any maintenance engineer can make use of this remedy.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Voltage Rating of Lamps Used for Synchronizing—In synchronizing two 440-volt alternators by using lamps in case the synchroscope should fail, what voltage rating of lamps should I use and how many of them? Should I provide lamps enough for 880 volts or 440 volts?
Indiana Harbor, Ind. A. R. D.

• • • •

Will Shorting Slip Rings Injure Motor?—Will short-circuiting the slip rings on a three-phase, wound-rotor, induction motor damage it? This is likely to happen when the external resistance is entirely cut out of the circuit so as to speed up the motor as much as possible. What takes place when one or more of the brushes do not make contact with the slip rings of such a motor?
Milwaukee, Wis. B. R. B.

• • • •

Calculation of Winding for Induction Motor—Will some reader please show me how to calculate the winding for a motor which has the following dimensions: Bore, 6 in.; outside diameter, 10 in.; slot depth, 1⅛ in.; axial length of core, 3⅞ in.; tooth width, 3/16 in.; number of slots, 36. I wish to have this motor operate at 220 volts, three phase, 600 r.p.m. What will be the horsepower of this motor, approximately?
Aurora, Ill. J. L. H.

• • • •

How Should a Delta-Connected Transformer Bank be Grounded?—I should like to know some of the standard or practical methods of grounding a delta-delta connected bank of transformers. We have a transformer bank consisting of three single-phase, 13,200/400-volt transformers, which are delta connected on both the high- and low-tension sides. Now I get a reading of about 100 volts from each 440-volt bus to ground. Consequently, I am planning to ground the low-tension side of the transformer bank. Can some reader tell me to what part of the low-tension delta I should connect my ground or what reactors or other devices I must use to obtain my ground connection?
Omaha, Neb. G. C. B.

• • • •

Strength of Brick Walls—We can find very little test data on the strength of brick walls with respect to forces acting against the wall horizontally and at right angles to the plane of the wall. If any readers have pulled down old brick walls they may be able to give me some data regarding the force required.

Suppose we have a brick wall three courses thick, 36 ft. high and 60 ft. long, with no openings and supported at each end by being tied to side walls of the same height and thickness. Assume that this wall has been standing for over a year and was constructed of No. 1 red brick and good mortar, well laid, with header courses placed in the standard manner.

What would be the approximate force required to pull this wall down, assuming the force to be applied at a point half-way up the wall and midway between the ends?
Bowmanville, Ont., Can. L. J. C.

• • • •

Operating Direct-Current Motor as Generator—We have a Century Electric, compound-wound, d. c. elevator motor rated at 220 volts, 52 amp., 1,200 r.p.m. which we wish to use as a generator to deliver 110 volts, 50-60 amp. I shall appreciate it if some reader will tell me whether it will be necessary to rewind or reconnect the armature, or if there is any way in which we can operate it as it is.
Caguanay, Que., Can. C. R.

• • • •

Winding Armatures With Asbestos-Covered Wire—I should like to get the experience of some of our readers as to the best methods of handling asbestos-covered wire when winding armature or field coils for mill-type and other heavy-duty motors. In what manner can I apply tension to the wire without mechanically injuring the asbestos insulation? What other kinks can you give me as to how I can best make up coils and wind armatures with wire having this kind of insulating covering.
Birmingham, Ala. L. A. C.

Answers Received To Questions Asked

Connecting Lineshaft Directly to Motor—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.
St. Louis, Mo. B. G. S.

Replying to B. G. S. in the April issue, I believe that you could make a very neat and efficient drive by connecting the lineshaft directly to the motor, by means of a flexible coupling, taking care to see that the lineshaft is properly aligned. The bearings should be spaced on short centers; then the chance of springing the shaft by the side pull of other shafts or machines will be small. The proposed speed of 870 r.p.m. is high, but many lineshafts will be found turning at that speed.

It would probably be better to support the lineshaft bearings on top of concrete posts or tapered piers. The piers should be of generous dimensions and well reinforced. Ball bearings should be used and should be mounted on an adjustable base or pillow block so that adjustments can be made in all directions. The bases of these bearings are made adjustable by the use of a combination of setscrews and wedges. The bearings are packed with soft grease and require very little attention after they are installed.

In our plant we have two drives similar to the one you have in mind excepting that they are shorter, being about 50 ft. in length. In both cases the shafts are driven at 900 r.p.m., and are standard shafting 3 15/16 in. in diameter, coupled directly to 100-hp. motors through solid flange couplings. This installation has been running for one and one-half years, 24 hr. a day, six days a week, and has never required any repairs. A few minor adjustments have been made, but the only charges that could be placed against repairs or maintenance is the cost of the grease for the bearings.

Special attention was paid to the installation of these drives; every part was accurately machined and carefully installed. SKF bearings are used on these two drives.
Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In the April issue B. G. S. asks whether it is practicable to drive a lineshaft at 870 r.p.m.

Driving a lineshaft at that speed is feasible, but much care must be exercised in its installation. First, he must limit the size of the pulleys (if made of cast iron) to 24 in. diameter, in order to keep the stress due to centrifugal force within the working strength of the material. Second, he must do a thorough job of balancing the pulleys because a slightly unbalanced condition will produce great vibration at that speed. Third, he must get a thorough job of alignment in order to reduce destructive "whipping."

The kind of bearing is immaterial. If there is a large starting-load, ball or roller bearings will be advantageous; sleeve bearings, however, will be entirely satisfactory. Whether to support the shafting on the top or sides of posts

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depends on conditions. If placed on top, the posts must be braced below the bearings. Such bracing will detract from the appearance of the room, if it is not actually in the way. By securing the posts to the ceiling, the bearings can be bolted to the sides, with a minimum of construction work.

If the ceiling construction is capable of rigidly restraining the shafting, it would be best, from considerations of appearance and future layout, to place it there. Posts in buildings have caused me a lot of grief. Their interference with good layout is out of all proportion to their size and importance. I once replaced two building posts with a truss and succeeded in improving the equipment layout so that the working force was reduced by three men.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

Referring to B. G. S.'s questions in the April issue, (1) operating a lineshaft 100 ft. long at 870 r.p.m. is not practicable. Without knowing the service conditions, that is, the kind and type of machines that are to be driven from the lineshaft, it is difficult to say what the r.p.m. should be. For machine shop service 200 to 250 r.p.m. is desired; for woodworking shops 240 to 250 r.p.m. is used and for envelope machines, small printing machines and the like about 200 r.p.m. is being used.

(2) Supporting the shaft on top of the posts would be more desirable, using either the inverted shaft hanger or pedestal-type pillow blocks. Concrete posts with their foundations resting on good, hard sub-soil and independent of the building foundations, are practicable for such service. Mounting the bearings on the side of the posts is feasible, but more expensive and in some cases requires more maintenance.

(3) Vibration depends on the size of the shaft, its speed, distance between hangers, the number of driving pulleys between hangers, and the nature of the load or kind of machines driven. The spacing of hangers may be from 10 to 15 ft., and the load should be equally distributed near the hangers, with the light machines placed in the middle of the hangers. The motor should be placed in about the middle of the shaft so as to divide the torsion in the shaft. The heaviest load should be pulled near the motor, and the lighter load at the ends of the shaft. If certain machines are to be idle at times, it would be advisable to group them and divide the lineshaft into sections, with mechanical clutches or magnetic clutches to disengage the sections not in use. This arrangement has the advantage that should a breakdown or accident occur on some machine, that section can quickly be thrown out of service without holding up production on all machines.

A large diameter shaft, close spacing of hangers, and a lower speed than is stated in the question, will keep the vibration within safe limits.

(4) A roller bearing made in two halves or sections would be practicable and economical for this installation and would lower the cost of maintenance.

The motor could be arranged to drive the lineshaft by means of a silent chain drive which is economical, silent, positive and low in maintenance cost. Placing the motor on a platform or foundation elevated from the floor so as to have about 30- to 40-in. shaft centers is practicable. For this installation a 1¼-in. pitch by 5-in. wide, continuous-duty chain would be required. This would cost approximately $170.

Engineering Dept., E. H. LAABS.
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

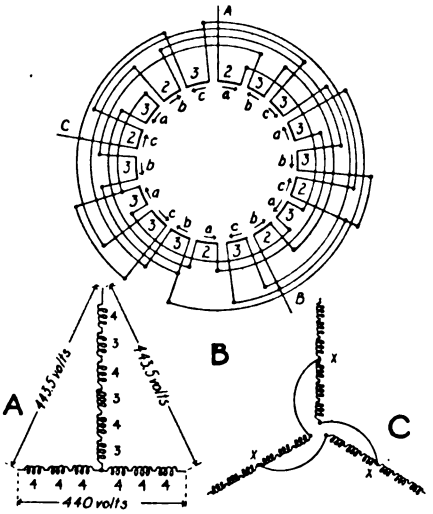
* * * *

Reconnecting Two-Phase Motor for Three-Phase Operation—I have a 10-hp., 440-volt, two-phase, squirrel-cage motor which has 48 slots and coils, six poles, and is series-connected. Can this motor be reconnected for three-phase operation by using the "T" connection? If so, how many coils must be cut out of circuit? What will the new grouping be for three phase and what horsepower will the motor develop after reconnection, if the speed remains the same as before? What is the smallest number of coils that can be reconnected from two-phase to three phase by the "T" connection?

Iola, Kan. G. E. G.

Answering G. E. G. in a late issue, *A* in the illustration shows the number of coils per pole for a six-pole winding T-connected for three-phase, approximately balanced voltage. The voltages shown are the phase voltages for actual balance. This diagram shows that three coils will be cut out of the phase making the T-connection. The grouping for one phase is the same as in the two-phase winding. The horsepower developed by this motor after reconnection, will, at the same temperature rating, be approximately 78 per cent of the nameplate rating. The number of coils remaining in the phase forming the T-connection, should be approximately 87 per cent of the coils in the two-phase winding. Any number of coils can be connected in this manner, but very few combinations will give much closer than 1 per cent voltage balance.

The connection diagram shown in *B* is one which I have frequently employed. This makes use of all coils, gives the exact voltage balance between phases and is within 3 per cent of the voltage of the nameplate rating. *C* is a schematic diagram corresponding to *B* and shows the coils per pole for a four-pole winding. The grouping for a six-pole winding will be as follows: 233-332-323-233-332-323. Care must be taken to start the phases so that the connection at *x* in diagram *C* will include in the delta section of the winding the same number of coils in each phase. The horsepower output with this winding will be approximately the same as for the T-connection.



Connections for changing two-phase motor for three-phase operation.

A, number of coils per pole in six-pole winding connected in T; *B*, connection diagram for changing from two phase to three phase, using all coils; *C*, schematic diagram of winding shown in *B*.

In both of these windings the size of the wire is the feature governing the output, up to the nameplate rating of the motor. CHARLES R. SUGG.

Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

* * * *

Should Coils Be Purchased or Made in the Repair Shop?—We have in our plant about 1,000 motors ranging from 3 hp. to 100 hp. Roughly, one-third of these are older-type motors, while the remainder are of modern type. We have our repair shop, but so far have not attempted to wind our own coils. There is a feeling that we should do this, but before making any decision I should like to get the opinion of readers of INDUSTRIAL ENGINEER on the feasibility of doing this work. Will it pay us to do it? Can anyone give me some idea of the nature and approximate cost of the equipment needed?

I shall be very grateful for any information or suggestions you can give me.

Chicago, Ill. L. A. M.

With reference to the discussion in the March issue of L. A. M.'s question, I should like to add the following from our experience.

The same question came up several months ago in our plant. We have about 300 motors, mostly d. c. and a fair percentage of these are old style and so-called obsolete. It is hard to get factory-made coils for these old motors and the deliveries on same are bad. Our experience was the same as Mr. Housley's, with factory-made coils, which lay in stock. Some of them required considerable renovating before they were of use to us, when needed. Some months ago we borrowed a set of Browning equipment, from the local distributor, for test. We selected a 25-hp. crane armature, containing 35 coils, which was in the shop for repair, for our test. Our cost for the set of coils was just under $25. The manufacturer's quotation was $65. From information obtained from their service man, we found that the overhead was the sole difference. Using the same overhead as they do, our cost worked out approximately the same as their quoted price.

We find it unnecessary to stock any large amount of round wire larger than No. 30 in any standard insulation, nor any large quantity of any usual thickness of insulating papers or tapes. We can obtain these, on a few hours' notice, from the local representatives of the manufacturers.

We stock only flat and square wire and unusual insulating materials.

In addition to our loop winder, spreader and reel stand, we purchased shears. These are great labor and material savers. They are particularly useful for cutting wedges.

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We built a brick, steam-heated oven, which will maintain a temperature of 240 deg. to 250 deg. F. We did not favor a gas-fired oven, due to the fire hazard inherent in the varnishes. We also built a dipping and impregnating outfit.

We conducted tests on varnishes and found that we could obtain a flexible varnish with high oil- and water-resisting characteristics. Therefore, we use but one grade of baking varnish. Our tests showed us, further, that the baking varnishes are incomparably superior to the air drying varieties. We are, therefore, dipping and baking everything that we can.

Last, but not least, I would add the warning: Don't skimp on quantity or quality of any insulating material. On the job mentioned wire, labor and overhead constituted better than 90 per cent of the cost. The balance was for sleeving, tape, varnish, etc. This being the case, the value of these items affect the cost of finished coils but little. However, the excellence of the insulation is the determining factor in how long the coils will last. In addition to the coil cost, we have the cost of installing the coils in the armature. If this be added to the cost of a set of coils, the percentage of the whole which is due to insulation becomes negligible.

G. R. HOFMANN.
Supt., Light, Heat & Power Dept.,
National Metal Molding Co.,
Ambridge, Pa.

* * * *

I was interested in L. A. M.'s question in a recent issue, because it is a much-discussed subject in plants that have a large number of motors. I believe that a plant that has as many as 250 motors should have the mechanics and equipment to do their own work, that is, winding and general repair, but I do not believe that this is a paying proposition in the smaller plants.

In his case there is no reason why his company could not easily install equipment and wind their own coils, because they already have a repair shop. I believe, however, that should they do this, it would be advisable to have an expert coil winder in charge of the various operations in making coils, as the coils are the heart of the machine and no winder can do a thorough job with imperfect coils. I would like to say in connection with this that very few armature winders are good coil makers and that coil making is a trade in itself.

The most expensive items in the list of coil winding equipment are the steam press for shaping, and the impregnating tanks. The ordinary dipping tanks could be built in your own shop of about No. 10 gage sheet iron. The winding machine and the spreading machine invented and patented by S. J. Browning and sold by the Mutual Foundry Co. of Atlanta, Ga., are one of the most up-to-date sets on the market. This company also sells wire racks and a spooling machine. Prices of this equipment can be obtained from either the manufacturers or Mr. Browning himself. Two or three taping machines would probably be necessary for a plant having the above number of motors. These taping machines may be bought from the Electric Service Supplies Co., Philadelphia, Pa.

A winding shop should have a lathe or a combination banding machine, as practically all d. c. machines and many a. c. machines have wire bands. Also, the commutators and slip rings should be turned in the shop under the shop foreman's supervision. Armature racks can be purchased or built in your own plant. They should be built individually to suit the winder or be adjustable in height, as an armature placed too high or too low is difficult to wind. For stators of the smaller sizes a table of heavy construction may be used; it is a good idea to have casters on the table legs. A bench well lighted and provided with drawers for tools is a real necessity.

Acmar, Ala. GRADY H. EMERSON.

* * * *

In reply to the question by L. A. M. in a recent issue, the situation should be analyzed in all its phases before assuming the responsibility of winding and treating coils in an effort to reduce the eventual cost. However, if any delay is being experienced in procuring factory coils, I would suggest that they be made in the repair shop.

With very little equipment one can make coils for small a. c. partially-closed slot machines, that for service will equal the factory coil. Serviceable formed coils for open-slot machines can also be easily made, but a little more equipment is required.

The nature and cost of this equipment are two of the factors which govern the quality and cost of the finished coil and should be determined after the quantity of coils to be manufactured has been carefully estimated. If that quantity is sufficient to justify the installation of a reasonable amount of equipment and the employment of labor for that particular purpose, there is no doubt that it is feasible to make your own coils, especially when it is realized that repairs can be made independently of any unforeseen delays in the delivery of coils from the manufacturer. Further, the first cost of the winding equipment should not be in excess of the investment involved in a stock of factory coils for even a part of the 1,000 motors.

On the other hand, many of the modern motors mentioned are likely to be wound with rectangular wire or ribbon, which are not always procurable on short notice; in such cases, round wire may have to be substituted. This is being done when necessary but much can be saved by using factory coils in these motors. Winding machines and adjustable forms which have proven very satisfactory are on the market.

Should the quantity of coils to be manufactured be considered insufficient to justify the investment required to install this special equipment, a lathe can be used, preferably with a hollow spindle, to facilitate the winding of loops beyond the lathe bed, as otherwise the lathe may not swing the larger forms. Many shops are using a worm drive mounted on a heavy table and driven by a 1-hp., d. c. motor controlled by a foot pedal. Tension on the wire may be secured by means of fibre or hardwood clamps.

I would not advise the expenditure of much time or money on an elaborate, adjustable form for winding loops for among the 1,000 motors no doubt many are identical and a good hardwood form is not difficult to make; after it is once used, it can be marked and stored away for future use.

A spreading machine should not be a necessity for the quantity of coils likely to be pulled out, although these machines do nice work and save time. A skilled winder can, with a little care, form at the bench coils that will be symmetrical enough for all practical purposes.

If it is desired to treat coils in baking varnish an oven will be a necessity, but it should not be expensive as it need not be large and can be electrically heated.

I would not recommend the manufacture of coils for 2,200-volt machines as they cannot be properly treated without more elaborate equipment.

Factory coils are a product developed by some of the best talent in the motor manufacturing industry and it has been my experience that with the exception of those for some small machines, they are everything that could be desired when winding a machine in an effort to reduce the chances of future trouble to a minimum.

San Francisco, Calif. W. O. HURLBUT.

* * * *

Answering the question by L. A. M. in a recent issue, he can make a substantial saving by winding coils in his own shop. In addition to the saving in the winding of the coils, better service will be obtained from your own shop. When coils are bought from an outside concern it often happens that there is a delay in getting them just when they are wanted. This, in turn, may delay the rewinding of a motor which may be very urgently needed.

The equipment required varies, depending upon the amount of work to be done. Some shops use a wooden form cut to the size and shape of a coil. A separate form must be used for each different size and shape of coil. A form which can be adjusted to wind different sizes and different shapes of coils can be made at small cost. This can be turned by hand or driven by a motor.

On page 19 of the December issue of INDUSTRIAL ENGINEER, a coil winding and forming machine, operated by a motor, is advertised by the Armature Coil Equipment Company, Cleveland, Ohio. I would suggest that L. A. M. write this company for further details and prices.

Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to the inquiry by L. A. M. in a recent issue of INDUSTRIAL ENGINEER, we are glad to express our opinion, as it may help him to solve his problem.

In our opinion, a plant having 1,000 motors and located in Chicago can be better serviced by the repair trade than by a repair shop in the plant itself, equipped for rewinding. If such a fac-

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tory were removed from an industrial center it would beyond a doubt be advisable to rewind the motors right in the factory, but in a place like Chicago there are 15 or 20 repair shops which are equipped to do this rewinding at any hour of the day or night and at prices which are probably below the cost of any shop located in the factory. Of course, these lowered costs are due to the large scale on which this rewinding is done in the modern repair shop.

The necessary equipment for rewinding would include winding and spreading machines which would represent an investment of $500 or $600, together with impregnating and baking equipment. The necessary stocks of magnet wire and insulating material would also tie up considerable money. Although we are in the magnet wire business and have a great deal of direct-driven equipment we do not do our own rewinding. G. B. FINCH.

Magnet Wire Dept.,
Belden Manufacturing Co.,
Chicago, Ill.

* * * *

In reply to L. A. M.'s question in a recent issue, I have worked in some plants where they did not make their own coils and in others where they did make them. It is my opinion that with the number of motors you have, it would pay you to make your own coils. I am sure that you will be able to realize a saving of at least 50 per cent over what you have to pay for factory coils. Also, your stock will be more flexible and the investment in spare coils will be reduced.

As to equipment needed, I would suggest that you investigate the new Master combined loop winder and coil spreader manufactured by the Armature Coil Equipment Company, Cleveland, Ohio. This machine is a big time saver, does accurate work and is substantially built. You will also want to investigate the taping machine made by this same company. As to other equipment, you will need a wire rack with tension blocks, baking oven, dipping tank for insulating varnish, etc. The total cost of this equipment should not exceed $1,000, including the setting up of the winding and taping machines which should have individual motor drive.

Chief City Electrician, H. J. ACHEE.
Woodward, Okla.

* * * *

Determining Size of Conductors for Intermittent-Rated Motors—Will some reader of INDUSTRIAL ENGINEER please give a method of computing the sizes of rubber-covered cables to be used for connecting intermittent-rated motors—particularly half-hour rated crane motors?

Montreal, Can. F. P.

Replying to the question by F. P. in a recent issue, the carrying capacity of wires has only one rating, and that is the rating which is allowed by the Underwriters. I would advise F. P. to consult a table of the current-carrying capacities of conductors and from it select a size of wire that will safely carry the maximum current which it will be called upon to handle, or that will have at least 110 per cent of the motor nameplate current rating. Some motors have intermittent ratings which permit the use of a motor that is smaller than would be necessary if the maximum load were carried continuously. This is not the case with conductors; their rating and size should be selected for maximum load.

Muncie, Ind. GEORGE CROPPER.

* * * *

Answering the question by F. P. in a late issue, the formula for computing the size of wires and cables, including rubber covered cable, is, C. M. $=L\times K\times C\div E$ drop.

In this formula *C. M.* represents the size of the conductor in circ. mils (1 mil=.001 in.). *L* is the length of the wire in feet. The length used should be double the length of feeder. *K* is a constant, which equals 10.8 ohms per mil-foot for copper wire. *C* equals current in amperes. The value of *C* in the case you mention should be 110 per cent of the nameplate current rating of the motor. (See Article 8, National Electrical Code, for percentage of nameplate current rating.) *E* drop represents the allowable voltage drop in the line, usually 2 per cent of the supply voltage in feeders.

This formula takes account of the *E* drop in the line; that is, a wire of the size obtained by the formula will carry the current without causing more than the allowable 2 per cent *E* drop, but it may not carry the current in accordance with Table 1, Article 6 of the 1923 National Electrical Code. The reason for this is that if a wire is short it may carry considerable current, causing only a small voltage drop; on the other hand, if the wire is long, even if carrying far less than its allowable current, it may cause an *E* drop much greater than the allowable 2 per cent. Because the formula takes account of *E* drop only one must always refer to Article 6, Table 1, after computing the size of the wire with the formula, and see that the allowable carrying capacities therein are not exceeded. This means, for example, that if the size of wire obtained were 26,000 circ. mil (the nearest size in the B. & S. gage is No. 6 or 26,250 cir. mil) and the current 65 amp., No. 4 wire would have to be used, if it is rubber covered. (See Article 6, Table 1, of the Code.)

In addition to the above, a conductor feeding one a. c. crane motor with a 30-min. rating must have an allowable carrying capacity of 110 per cent of the nameplate current rating of the motor. Thus, when referring to the table as above, 10 per cent must be added to the nameplate current of the motor.

When a. c. motors of the type requiring large starting current are started without the use of auto-starters, the starting current may be more than double the normal running current. The necessary current-carrying capacity of conductors in that part of the circuit supplying the motor, which is between the motor running protective device and the mains, will not exceed 300 per cent of the nameplate current of the motor. Motors rated from 0 to 30 amp. will require starting leads having a carrying capacity of not over 200 per cent of their nameplate current rating. Suppose you were computing the size of conductors feeding a motor having a full-load current of, say 50 amp.; the starting current would be not more than 100 amp. The conductors that must carry this starting current should have an allowable carrying capacity of 100 amp. After computing the size with the formula, refer to the table and see that the conductor to be used has an allowable carrying capacity of 200 per cent of the nameplate current of the motor.

In figuring the size of mains used to feed several d. c. motors, add together the full-load currents of all the motors and assume that the current in the mains will never exceed 60 to 75 per cent of this sum. This per cent is the demand factor and should be used as the value of *C* when figuring the size of mains.

To figure the size of a main serving several a. c. motors follow the same directions outlined above except that the demand factor should be larger. Where specific information is not available a demand factor of 80 per cent may be used. (See Croft's "Wiring for Light and Power," pages 73-74.) A larger demand factor should be used than in the case of d. c. motors, because of the large starting current required by a. c. motors.

To figure the size of conductors in two-phase circuits, first figure as single-phase; then take 50 per cent of the circ. mil obtained by the formula. Take the nearest size in B. & S. gage to the result obtained, referring to Article 6, Table 1, as to current-carrying capacity, as shown above. Figure the size of wire for three-phase circuits the same as for two-phase except that 58 per cent of the circ. mil obtained by the formula is used in place of 50 per cent.

Concord, Mass. DONALD FERGUSON.

* * * *

Replying to F. P. in a recent issue of INDUSTRIAL ENGINEER, if the motors in question are mounted on a crane it is usual to figure the capacity of the line contactor on the protective panel as being equal to, or greater than, one-half the sum of the full-load currents of all the motors. Furthermore, the contactor should be large enough to carry the full-load current of the largest motor continuously. The cables should then have the same current capacity as the contactor. For example, a crane may be equipped with a hoist motor, bridge propelling motor and trolley motor, all rated on a 30-min. basis and having full-load currents of 280, 150 and 50 amp., respectively, making a total of 480 amp.; one-half of this is 240 amp. The next larger size contactor is rated at 300 amp. and this rating should determine the size of the cables, because the largest motor draws less than 300 amp. If the largest motor is rated above 300 amp., this should be taken into consideration.

In regard to the wiring for individual motors, it is questionable whether any allowance should be made, due to the fact that the motors are rated on an intermittent basis, particularly in the case of induction motors. General Electric type MTC crane motors will in general stand 65 to 80 per cent of their rated full load continuously, depending on the size of the motor. MTC motors above 40-hp. rating will stand

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80 per cent of their rated load continuously. It should be borne in mind that the maximum torque developed by an induction motor varies as the square of the applied voltage. This is approximately true whether the motor is at rest or running. For example, a drop of 10 per cent in voltage means that the maximum torque the motor can exert drops to 81 per cent of what it could develop at normal voltage. Since the current taken at starting is likely to be several times the full-load current of the motor, it is very important that the connecting cables be large enough so that there will be no undue loss in voltage in the cables. In case a crane hoist motor were called on to make an extra heavy lift, it is quite possible that loss of voltage in too small connecting cables would be so great as to prevent the motor from starting the load, which it would be able to do if full rated voltage could be brought to the motor terminals.

In the case of d. c. series crane motors, the torque exerted is not dependent on voltage, and a reduction in cable size due to the intermittent character of the load is not such a serious draw-back as in the case of induction motors.

R. F. EMERSON.
Industrial Engineering Dept.
General Electric Co.,
Schenectady, N. Y.

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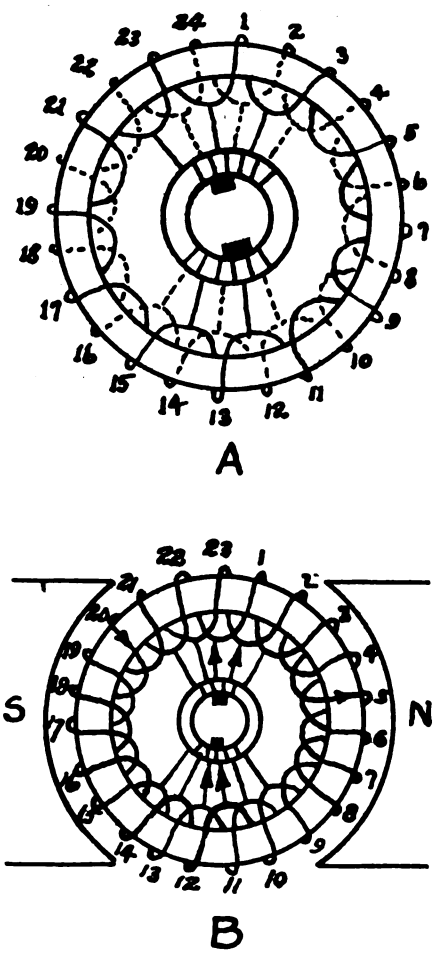
Number of Bars Covered by Brushes on Wave-wound D. C. Armatures—I should like to know why the brushes on a 4-circuit, wave-wound, d. c. armature cover only a little more than one segment, instead of two or more segments. I was, until recently, under the impression that the brushes had to cover as many segments as there are circuits per coil. If not, why have the four circuits?

Wichita, Kan. E. E. B.

E. E. B.'s question in a late issue may be answered with the help of the accompanying diagram. For the sake of simplicity, two-pole, ring-wound armatures are shown at *A* and *B*. This illustration will be clearer than would a typical winding of the barrel type, that is, wave or lap wound, and does not depart from the problem since for any two-pole winding the number of independent brush sets must of necessity be two. In any case, the number of armature circuits in parallel is two so that our analogy is correct. If two identically wound machines are connected in parallel at their terminals, the combined current output will be double that of either machine alone. This same result can be obtained, with a consequent saving in material, by placing two independent windings upon the same armature core and subjecting them to the influence of the same field structure, as shown in *A*. Not only are the coil sides sandwiched together but the commutator segments connected to the independent windings are intermeshed as well. This is an example of a duplex winding built up as described of two separate simplex windings.

Any desired number of separate windings may be interleaved in this manner, but it will be noted that the intermeshing of the commutator segments requires the application of brushes whose width will be sufficient to collect the current from each pair of circuits at the neutral zone. Since simplex wave-wound armatures have two armature circuits in parallel irrespective of the number of poles, it follows that duplex wave windings will always have four parallel circuits or paths, independently of the number of poles.

The arrangement shown in *A* illustrates two entirely separate windings, each containing 12 elements, or 24 in all. Let us suppose now that one of the 24 elements is omitted and that the remaining 23 elements, uniformly spaced, are connected alternately as in *B*. We no longer have two independent windings each closed in itself as in *A*. There is now but a single closure. However, it will be noted that in passing from one brush to the other four paths in parallel are encountered, as in *A*. In short, both *A* and *B* illustrate duplex windings. The winding in *A* is known as a duplex, doubly-reentrant winding since on arriving at the starting point after tracing through the given connections, it is found that only half the total number of conductors has been encountered and it is necessary to trace through the remaining half at the end of which a second closure occurs. Winding *B* is a singly-reentrant duplex winding since all coils are traversed in reaching the first closure, although it is necessary to travel twice around the armature. In similar fashion, we could have a triplex, singly-reentrant wave winding, giving six circuits in parallel, and still properly commutated by a brush spread of not more than two segments.



Doubly-reentrant, duplex armature winding, A, and singly-reentrant duplex winding, B.

From the above, the degree of reentrancy may be defined as the number of independent, separately-closed windings on the armature.

Engineering Dept., CECIL H. GREEN.
General Electric Co.,
Schenectady, N. Y.

* * * *

Using A. C. Generator as Synchronous Motor—What changes, if any, are necessary in order to use a stationary-field, revolving-armature, a.c. generator as a synchronous motor? This is a Westinghouse generator, rated at 25 kva., 480 volts, 30 amp., three-phase 60 cycles, 1,800 r.p.m., serial No. 3212835. The exciter is direct-connected to the generator shaft and is rated at ¾ kw., 125 volts, 6 amp.

I should like to use this generator as a synchronous motor to drive a centrifugal sugar drier and to correct power factor. The power supply is 480 volts and all motors are rated 440 volts. If I can use this generator as planned, what horsepower will be developed and what will be the ampere input? Will I have to have an outside supply of direct current for excitation, or can I use the exciter on the machine?

Negros Occidental, P. I. A. C. M.

In reply to A. C. M.'s question in a recent issue, no changes will be necessary, providing the machine is equipped with a damper winding to be used in starting. An auto-transformer will be needed to impress a low starting voltage on the windings to prevent a sudden rush of current and the fields should be short-circuited until the machine is up to speed and thrown on the line. Then the fields should be thrown across the exciter, which will have built up its voltage by this time.

No outside supply of direct current will be necessary, as the exciter is used to excite the fields. If the machine has no damper winding, it may be brought up to speed as mentioned above, if it can be cut entirely free from its mechanical load, by relying on the eddy currents in the pole faces for its starting torque. This motor will operate successfully on 440 volts and if the mechanical load does not overload the motor electrically, the remaining energy may be used to correct power factor. The a. c. ampere input when the machine is used as a motor should not exceed its output as a generator.

As A. C. M. does not tell the power factor rating of this machine the horsepower cannot be accurately computed, but the following formula may help him.

For three-phase motors and generators, $I=\frac{W}{1.732\,E\times P.F.}=\frac{0.578\times W.}{E\times P.F.}$.

Where E=voltage, I=current per phase, $P.F.$=power factor, W=watts.

The value of W may be found from the formula: $W=1.732\times E\times I\times P.F.$

Alternating current generators and synchronous motors are rated either in kva. or kw., generally the former, and the power factor is usually specified on the nameplate. The capacity depends on the temperature rise, which in turn depends on the current flowing in the armature and field; therefore, neither term alone gives the true capacity. The safe load for a motor, expressed both in kva. and kw., is a

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maximum when the power factor is unity. Field heating increases, and the maximum safe load both in kva. and kw. decreases with the power factor.

Service Engineer, G. B. HERON.
Westinghouse Electric & Mfg. Co.,
Columbus, Ohio.

* * * *

Locating Trouble in Power Circuits Run in Conduit—Can some reader tell me what is the usual method of testing for and locating short-circuits, grounds and so on in power circuits which are run in conduit, and from which branch circuits for motors and other equipment are taken off at intervals? I shall be very grateful for your suggestions and advice.

Pittsburgh, Pa. J. L. B.

Referring to the question by J. L. B. in a recent issue, I have found that trouble on conduit systems can be located, in most cases, by the use of a test lamp or a magneto test set. In using the test lamp, each branch is disconnected from the main circuit and the lamp tips are touched, one to the conduit where it has been cleaned and the other alternately to each of the feed wires. If the lamp lights it indicates that the trouble is still ahead of the tester, and this procedure can be followed until the branch on which the trouble occurs is disconnected; then the lamp will remain dark. When the trouble is not heavy enough to use the lamp test it is necessary to resort to the magneto test set.

Make sure that the circuit is dead and proceed as with the lamp test. If the bell rings it indicates trouble in the circuit under test; no bell indicates a clear circuit. Often the magneto is not advisable, especially in the testing of large power cables, as the capacity effect of the cable is often large enough to cause the test bell to ring when the line is really clear.

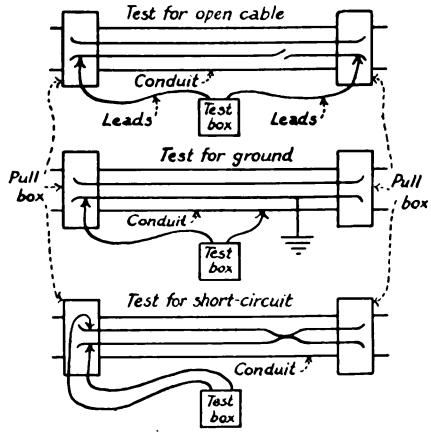
Goldfield, Nev. PHIL D. COMER.

* * * *

In answer to the question by J. L. B. in a late issue, several methods can be resorted to. Our susual method is to start at a point on the line in which trouble exists, say the main cutout or switch. We open the cable at the first branch cutout or pull box and test same out for breaks, short-circuits, grounds, etc., first by the use of a common battery-buzzer set. If no results are forthcoming we resort to a lampbank. When a cable is proved O. K. we repeat the test on the next section, etc., until the defective one is located. In case neither of these test sets prove effective we resort to a transformer to provide a selection of test voltages and currents as needed.

Continuing these tests from one outlet to another in the conduit run will show the cables either O. K. or defective and when the defective cable is found it can be repaired or replaced. It is good practice to test the entire line even after a defective part is located and repaired, thus assuring the elimination of possible additional defects.

In the diagram (only two cables are shown in conduit for simplicity) the methods for testing for short-circuits, breaks, and grounds are clearly shown. If the conduit run is long or should obstructions such as floors, walls, etc., be between two pull boxes the conduit can be used as one leg of the test circuit. However, it may prove ineffective, due to a poor or broken joint. I would advise that two wires of proven conductivity be used as test leads.



Methods of testing for defects in power circuits run in conduit.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

* * * *

Answering J. L. B. in a recent issue, I will endeavor to list some methods of testing power circuits that are run in conduit. These methods will probably aid him in testing for faults.

First open all switches, or otherwise disconnect all equipment and devices from the circuits to be tested. In some cases small equipment is connected to the line through fuses only; these fuses would have to be "pulled." After this is done, to test for a ground fasten one lead of magneto test set (commonly called "the mag") to the conduit and either hold the "mag" or insulate it from the floor or earth and touch the other lead to the individual conductors, while turning the crank. If one of the wires is grounded the bell will ring when the lead is touched to it. A lamp cut in series with a pair of leads will answer the same purpose if the ground is "dead" or the voltage of the circuit is low. For average testing a 16,000-ohm magneto is sufficient. For high-voltage testing, 6,600 volts and above, a 35,000- or 50,000-ohm magneto is better. In a test for short-circuits, tie one wire of the magneto to one of the conductors and touch all other conductors while turning magneto handle. It is a good idea to touch the magneto leads together before each test to be sure of good contact. Also be sure that the enamel is scraped off the conduit at the point of contact of the magneto leads. When testing oily conductors, such as transformer leads, wipe clean, as all oils are more or less insulators. In a test for short-circuits in long runs or where the conduit is run through floors, it is impracticable to have magneto leads long enough to reach from one end of the conductor to the other; so just ground the conductor, then test as if testing for a ground. When the right wire is found the bell will ring. Then the wire can be tagged at each end. In testing for open-circuits ground all wires in the conduit at one end and test all conductors at the other end as if testing for a ground. The conductors on which the magneto bell does not ring are open.

Of course, a battery and bell or buzzer can be used for the above tests, if desired, on low-voltage circuits. These are all reliable tests that are both simple and practical.

Acmar, Ala. GRADY H. EMERSON.

* * * *

Answering J. L. B. in a late issue, the usual method is to start at the beginning of a circuit, that, is at the main switch of the switchboard or supply point, and proceed from tap-off point to tap-off point, disconnecting each branch circuit and testing to ground or between conductors until the trouble has been localized in the main circuit or one of the branch circuits. It is assumed, of course, that the equipment connected to each branch circuit is disconnected during the test.

The foregoing method, while a sure one, is slow and tedious, as it requires the disconnection or cutting off of each branch circuit. A much more rapid method in the case of a ground is to send a direct current of 2 to 3 amp. through the circuit made up of the grounded conductor and the conduit itself. This direct current should be reversed about five times a minute. The reversing may be done with a double-pole, double-throw switch operated by hand, or by a commutator driven by a small motor. While the current is flowing the tester may proceed along the circuit with a pocket compass and hold it close to the conduit as he moves along, or apply it at intervals of 50 to 100 ft. So long as the ground point has not been passed, the compass needle will swing from side to side in time with the reversing field around the conduit. A strong field with the reversals timed to suit the compass will almost make the needle spin on its pivot. When the grounded point is passed, there will be no movement of the needle and the tester can retrace his steps and locate the point very closely, usually within a foot or two of the ground, if the ground is a good one.

In the case of a swinging ground or one due to vibration, it is, of course, more difficult to locate it. This method has the great advantage that it is not necessary to cut or disconnect the branch circuits. Testing outfits which can be used for this purpose may be purchased. These send a high-frequency current through the grounded conductor and conduits and by means of the tone in the telephone headset and exploring coil, both of which are supplied with the outfit, the tester may locate the grounded point in a manner similar to the compass method.

Short-circuits can be located by proceeding from point to point and cutting or disconnecting the branch circuit. The reversing direct-current method or high-frequency method may be used, however, to a certain extent if the conductors can be partially removed from the conduit at the branch-off points so as to allow a field from the conduit to affect the compass or exploring coil.

C. OTTO VON DANNENBERG.
Porter and Sanderson,
New York, N. Y.

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In answer to the question asked by J. L. B. in a late issue, often it is not necessary to make a test to know that a short-circuit exists as, provided there are no grounds or overloads, short-circuits are indicated by fuses blowing or breakers tripping, and partial short-circuits by a creeping of the meter. Grounds may bring about the same results. Overloads may blow fuses or trip breakers.

To test for and locate short-circuits in power circuits installed in conduit a test lamp or testing magneto may be used. If a test lamp is used, first disconnect all branch circuits connected to the power circuit; then remove one fuse of the power circuit and connect the test lamp as the fuse was connected and note if the lamp burns. If it burns at full brilliancy there is a dead short-circuit in the circuit of which the lamp forms a part. If the lamp burns dimly there is a partial short-circuit, providing there are no grounds.

To test for short-circuits with a magneto, first disconnect the power circuit from all branch circuits; then open the service switch, or switch through which the power circuit receives its supply. After this, test out with a magneto. The ringing of the bell indicates a short-circuit.

To locate a short-circuit, disconnect at the panel boxes, in sections, the pair of wires which are short-circuited. How this disconnecting is done is explained in the following paragraphs on testing for and locating grounds. When the section containing the short-circuit has been located, provided it is in a section of conduit and not in cabinets or conduit fittings, remove the defective wire and pull in new wire.

To test for a ground a testing magneto is often used, or a test lamp may be employed when a testing magneto is not available. A test lamp, however, will not detect a ground of such high resistance as will a testing magneto. To test for and locate a ground on a power circuit with a magneto, first disconnect all branch circuits. This may be done by removing fuses through which the branch circuits receive their supply from the power circuit. Second, open service switch as when testing for short-circuits. Tests should first be made in the cabinet nearest the probable point of the ground. If this point is not known, begin at the panel box which is located at about the center of the power circuit and test by touching one lead of the test set to the box and the other to each conductor in turn. When the grounded conductor is found, disconnect it so that it will be in two sections. Now test, in the center panel box, the center of the section in which the ground is found, and disconnect as before.

Continue this process until the ground is located between two panel boxes. These tests have been made in panel boxes because in these boxes all the conductors are accessible without removing their insulation. The grounded conductor should be disconnected in a conduit fitting about midway between these panel boxes and tested each way as before. Finally the ground will be brought down to the conductor extending between two conduit fittings. If this short piece of wire still shows a ground it should be removed and a new piece pulled in.

Concord, Mass. DONALD FERGUSON.

* * * *

In answer to J. L. B. in a recent issue, when locating short-circuits and grounds in power circuits run in conduit it is of great advantage to have cutout boxes or busbar panels here and there along the lines. At these points the conductors can be parted, which helps to locate the trouble sought.

Then again, it is very necessary on a switchboard of any appreciable size, to have a ground detector voltmeter, or just plain ground lamps, so arranged that all feeders may be tested. The low glow of each lamp shows, of course, clear lines, but one extra bright lamp shows a ground. With the voltmeter and testing plug tests should be made often, at least once a day, on each leg of the system. When a switchboard is so equipped, a ground or short-circuit is not hard to find; it merely takes time. First, if a ground shows on the lamps or the meter, leave it there for a while; then when opportunity permits, as at noon, or after working hours, open first one and then another of the feeder switches for the various departments. Watch the detector and see what particular switch clears it off. This is the defective feeder circuit.

Close the switch, tag it, and allow the ground to show up again on the indicator. Then go along the line to the nearest busbar panel or cutouts and open all legs of the line; return and see if the ground is still showing on the detector. If so, the trouble is certainly between the switchboard and the first cutout or panel. If the ground fails to show, then this section of the line is OK., and the trouble is somewhere beyond it.

By the way, instead of returning to the switchboard to observe the detector each time a line is opened, a portable detector may be used, connected at the cutout or panel where the line is opened. This detector must be on the generator side, not on the far side.

This detector will indicate just as well as the one on the switchoard and may be made of one lamp, or a set of lamps, for each leg of the line; all these should be connected with a common return which is grounded to the conduit.

Make tests at first one cutout or busbar panel and then at the next, always connecting the portable ground detector on the generator side when the line is opened. Before long you will likely find a cutout which will still show the unbalanced ground lights when the line is opened. The trouble is between this point and the last place where the ground cleared off.

It is not a hard matter to locate such troubles, but it is often a very difficult job to pull out the conductor and draw in another. By the way, patching a bad spot with tape is not trustworthy, as it may ground again simply by pulling it in. The surest way is to draw in a new conductor; it is worth the price to get rid of the ground or short.

The writer has in this manner cleared off grounds showing up on the main switchboard when they were found to be simply a bare flexible lamp cord or two lying over an iron pipe at the far end of the plant.

In this case the portable detector showed its ground right out to the last cutout on the line; then there was nothing to do but to look over all the branch circuits. Such a stunt is not at all difficult; it merely takes time.

Jamestown, N. Y. H. S. RICH.

* * * *

In answer to J. L. B., in a recent issue, there are a number of ways of testing for grounds and short-circuits in power lines. I think that one of the quickest and most practical ways is to take out the fuses, both of which will probably be blown, of the main in which there is a short-circuit. These fuses should be replaced either by one fuse and a lamp or by two lamps. If the main carries 110 volts, a 110-volt lamp or lamps should be used. If the voltage is 220, a 220-volt lamp or two 110-volt lamps in series should be used, and so on according to the voltage of the main. If there is no other load on the line at the time of the test, the lamp or lamps will burn if a short-circuit exists.

The next step is to pull out the branch circuit switches, one at a time. As soon as the short-circuited branch is opened the light will go out.

Next, move the lamp up to one of the fuses of the branch circuit; then start at the middle and break the line. If the lamps go out, the short-circuit is beyond this break. Resolder the joints and move up to the next junction box and repeat the operation until the short-circuit is located.

If you are looking for a ground, make sure that the test lamp is in the grounded leg. I might mention here that when testing a lighting circuit by the lamp method, make sure that all lamps are out of their sockets or that the separate switches are open.

A testing magneto may also be used for locating trouble, but two men will be required. Personally, I do not like a magneto as it will often ring through when there is no ground, or at least no ground which is heavy enough to warrant taking out the wires. I had this experience on a 350-hp., 440-volt, 200-r.p.m. motor. The magneto indicated a ground, but the 440-volt test light would not light, nor could I get an arc when I touched the winding directly with the 440-volt lead without the lamps. This motor, which was a reversible and plugging type, was used on a coal hoist where it gets the roughest kind of treatment, but although this test was made eight or nine months ago, the motor is still running.

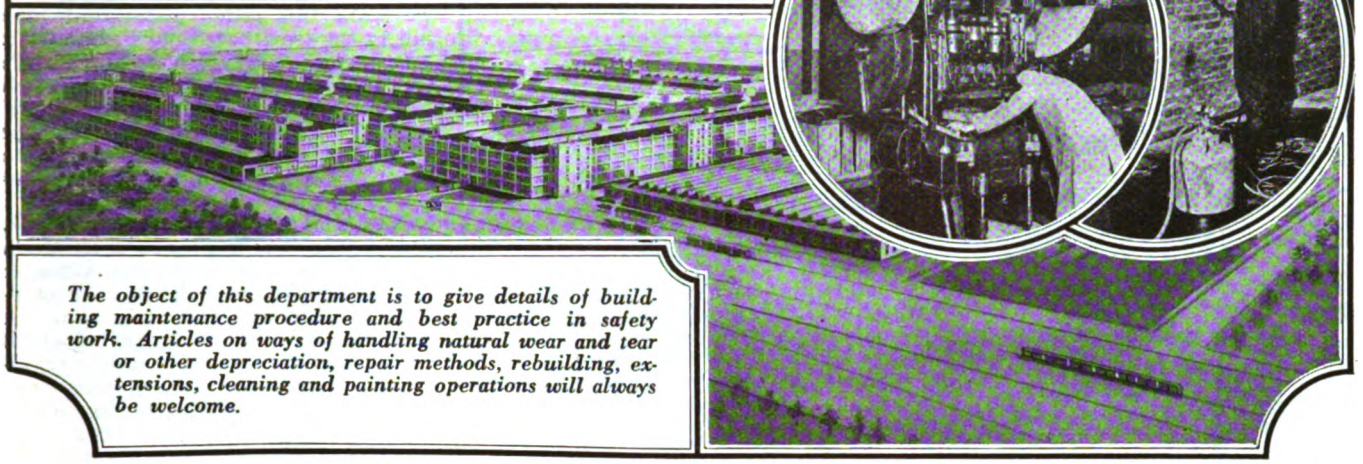
As to other methods of testing, there is the voltmeter method wherein by Ohm's law you can figure the resistance between one end of a grounded wire and the ground. This will give you an approximate idea of where to look for the ground, if you know the resistance of the wire per foot. There is also the Wheatstone bridge method.

NICHOLAS J. WEISS.

West New York, N. J.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

How to Make a Tumbling Drum Washer for Rags and Overalls

A SIMPLE washing machine, made from a vinegar barrel in a mounting upon which it can revolve, forms part of the equipment of a small shop and is used to wash out wiping rags as well as the greasy and dirt-laden clothes of the shop workmen. The simplicity and serviceability of this device are illustrated in the attached sketch, as being suitable for general use where time and the requirements make an inexpensive washer for heavy materials a feature worth adopting.

The first step in its construction is to open the barrel by removing a top hoop and one head. Large bolts, about 1 in. in diameter, are secured at the centers of each head, with washers on both faces, to form trunnions. Four or five strips of oak or other wood are fastened longitudinally inside the barrel as shown. These strips are made of 1-in. wood about 3-in. wide and, during the washing turn the clothes instead of permitting them to slide around. An opening about 6 in. by 7 in. is cut in the center of one side by cutting out a section of staves. This opening is used for inserting and removing the contents. The door is edged with rubber or some similar material to form a gasket and held with a small clamp.

A support frame is made from 2-in. by 4-in. planks to cradle the barrel on the bolt trunnions. This washing machine may be turned by hand if a handle is attached to one of the protruding bolts or it may be driven with a belt about the outer surface of the barrel. If a belt is used, a guide ring or plate is placed to prevent the belt from climbing the barrel. A flat pulley surface may be built up by using strips of old belt. The materials to be washed are placed in the barrel, which is then about half-filled with soap and hot water and revolved for half an hour. By that time the clothes are thoroughly cleaned of the heaviest dirt and grease. Where cleaning compounds are used it is well to see that they are not so strong as to damage the clothing.

Washington, D. C. G. A. LUERS.

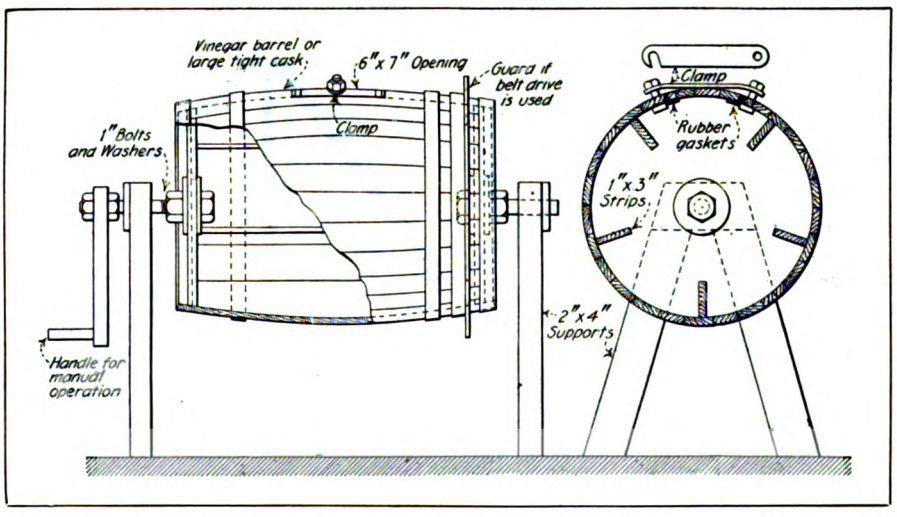
This shop washing machine may be easily constructed from an old barrel.

Standardized Identification Markings for Piping Systems

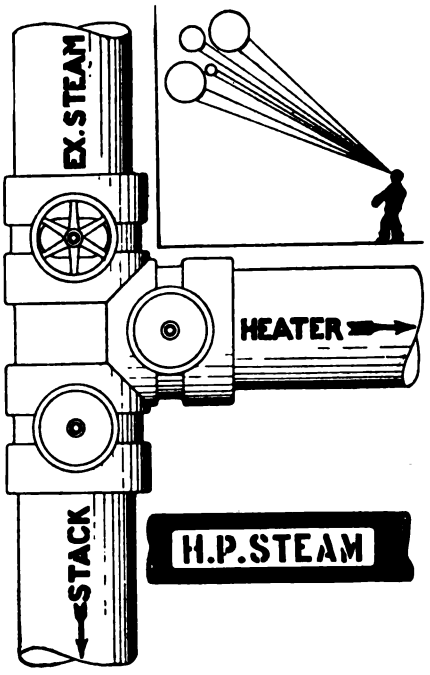
THE problem of devising some method of identifying pipe lines has been carefully studied by the Sub-Committee on "Identification Markings Other Than Color" under the sponsorship of the American Society of Mechanical Engineers and the National Safety Council. The first efforts of the committee were centered upon a combination of symbols or hieroglyphics along with a legend to designate the nature of the contained fluid or gas. This simple idea was discarded entirely because of the difficulty an operating force would encounter in recalling to mind the different shapes and forms of the symbols and their meanings, and the probable necessity for each industrial plant publishing its code.

It is recommended that the identification markings consist principally of a lettered legend, abbreviated or otherwise, which names the material carried in the pipe line. Where a knowledge of the direction of flow may be of service, it is suggested that arrows also be painted on the pipe. To make the marking more visible on pipe lines, which are located some distance above the normal line of the operator's vision, as shown in the upper right section of the accompanying sketch, the lettering should be placed below the horizontal center line of the pipe. Also, it is desirable where the view is unobstructed that the lettering be stenciled on the two lower quarters of the pipe coverings, rather than on one side only. Putting lettering on the under side will render it less liable to be obscured by dust collection or by mechanical damage of any nature.

In certain types of plants it may be desirable to label the pipes at junction points or points of distribution only, as is suggested by the accompanying sketch. In some power plants, the markings are repeated at intervals all



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Suggestions on markings for identifying pipe lines.

The sketch in the upper right-hand corner shows how overhead pipe lines should be marked on the lower side so that they may be more easily seen from the floor and also not be obstructed by dust deposits. The large sketch shows a recommended stenciling for pipe lines. Generally, pipe coverings are white; however, on black coverings or black pipe, it is well to stencil a spot with aluminum paint and then stencil the identification marking over it.

along the pipe line. In any case, the operating man should decide the location and number of signs required in each particular system of piping.

Stencils of standard sizes are easily obtained from any stencil manufacturer. The letters of these range in height from ½ to 3½ in. For pipe smaller than ¾ in. in diameter, identifying marks are best made by the use of a metal tag with the letters prominently indicated by etching and filling in with enamel. The accompanying tabulation shows the suggested height of stenciled letters for different outside diameters of pipe or pipe covering.

Vehicles have been developed, which with aluminum powder, make a paste that will stand up under temperatures ranging from 700 to 900 deg. F. without loss of color or adherence. Black letters for dark coverings may be either painted or stenciled on a rectangular background of aluminum paint, as shown in the lower right-hand corner of the accompanying sketch.

Recommended Stencil Sizes for Marking Pipe Coverings

Outside Dia. of Pipe or Covering, Inches	Size of Stencil Letter, Inches	Outside Dia. of Pipe or Covering, Inches	Size of Stencil Letter, Inches
¾	½	5	1½
1	½	6	1¾
1¼	½	7	2
1½	¾	8	2½
2	¾	9	2½
2½	⅞	10	3
3	⅞	11	3
3½	1¼	12	3½
4	1¼	13 and over	3½
4½	1½		

How Installing a Yard Crane Overcame a Bad Loading Condition

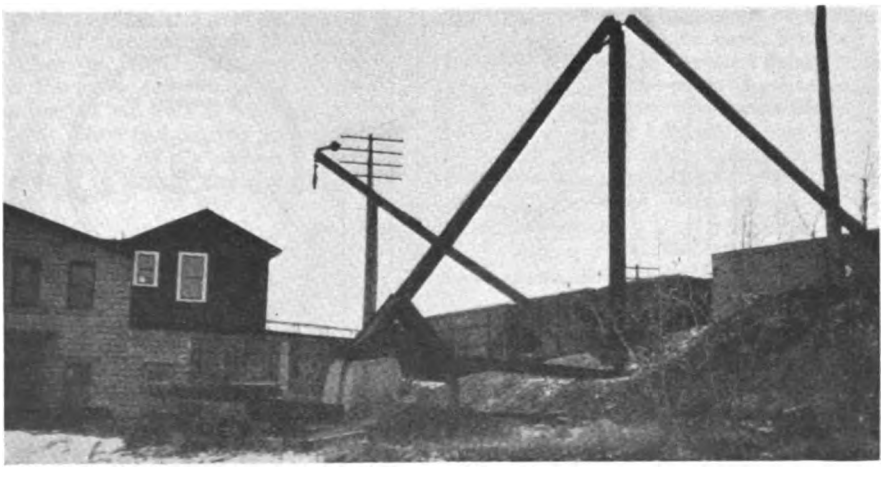
AT THE Bradney Machine Co.'s plant in Middletown, N. Y., the operating staff was confronted with a condition that seemed hard to overcome. The property had been purchased at a time when industrial buildings of any kind were at a premium. However, this one was ideal for the work of the new company, with the exception of loading and unloading cars on the adjoining siding. But a study of physical conditions showed the engineer that a yard crane could be used to handle this work to good advantage. Also it could be installed at no great expense. The cost of operation would be low, which was also an advantage in its favor.

The crane, as it was installed, is shown in the accompanying illustration. The 40-ft. boom swings through an arc of 180 deg., serves a storage yard for structural shapes and is used for loading the finished products on flat cars as well as for unloading. All shipments either way are handled through the local freight depot but incoming material, such as a carload of steel and outgoing fabricated products up to 10 tons in weight are placed on flat cars. To work this latter material up the hill to the track level and then hoist it 4 ft. higher ready to shove over on the car would cost as much as the profit on the work, if done by usual riggers' methods. Also, it would require the services of a number of men over a considerably longer period than it takes the crane to do it.

The crane is mounted on the bank, 2 ft. lower than the rails, 20 ft. from the center of the track, and a longer distance from the building, the shipping door of which is shown at the extreme left. A 2-ft. gage industrial track which runs out of that door parallels the structural storage ground and ends near the anchorage for one leg of the crane. Fabricated material for shipment from the shop is run outside on shop cars, picked up by the crane, hoisted and swung over on the cars—a distance of about 50 ft., and a difference in elevation of 14 ft. The cost of handling in this way is little more than if railroad cars ran directly into the building.

DONALD A. HAMPSON.
Plant Superintendent.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

This yard crane handles all heavy incoming and outgoing materials from cars to the shop, a distance of about 50 ft. and a difference in elevation of 14 ft.



One Method of Making a Close Seam When Laying Linoleum

INDUSTRIAL maintenance men are frequently called upon to lay linoleum in offices and other sections of industrial plants. The durability of linoleum when placed where considerable traffic crosses the seams in the abutting strips is dependent, to a large extent, upon the care used to obtain an unbroken layer of this floor covering. When seams do not meet evenly and without gapping and also when one edge of the linoleum stands slightly above the other, the result is visible and rapid wear at the junction.

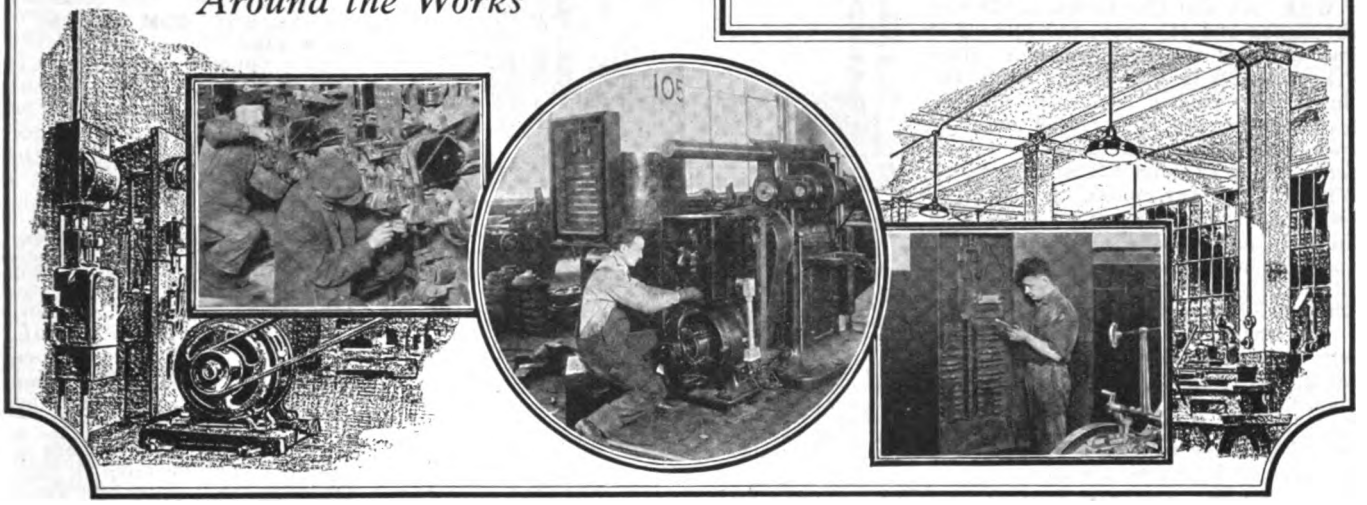
One method of making seams in linoleum and securing these seams to the floor so as to avoid the gap or upstanding edges, which was used by a carpenter in placing linoleum in an office building, is as follows: The first step was to overlap the edges of the linoleum and, with one edge as a guide, cut the adjacent strip to an exact fit. The edges of the linoleum were then turned back and the floor and the bottom edges of the linoleum were brush coated with a thick layer of spar varnish. After allowing this to dry for about 2 hr., the linoleum was pressed down to the floor and held by the tacky varnish. To keep the edges from rising a board was placed over the seam and ordinary building bricks placed on the board. The varnish was allowed to set for two days. The work was both neat and effective and the seam was almost invisible at the edges, as the varnish filled in the space between the two pieces.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Magnet Removes Tramp Iron in Cement Mill

IN THE process used by the Security Cement & Lime Company of Hagerstown, Md., for making cement, limestone and cinders are crushed in hammer mills and mixed before being placed in kilns to be burned to clinker, after which the clinker is ground to form cement.

The raw material is put through three different crushing operations, so that if any scrap iron is present in the material, it is certain to do considerable damage to the crusher. To remove any scrap iron or steel that may be present in the cinders or limestone, lifting magnets are placed over the conveyor belt leading to the crusher, in the manner shown in the accompanying illustration. The magnets used are the regular No. 3 lifting magnets made by the Electric Controller & Manufacturing Company. They are suspended fairly close to the conveyor belt and any iron or steel in the material on the belt is attracted and held.

The cinders are bought from railroads and power companies around the country. These companies have no reason to be careful about guarding against the presence of scrap iron or steel. For that reason the magnet that hangs over the cinder conveyor soon picks up a motley collection of junk. Bolts, nuts, broken tools and the like are in the pile of iron that is cleaned off of the magnets every day. As the company quarries its own limestone, the workmen are more careful and less iron is picked out of it by the magnet suspended over the limestone conveyor.

E. F. Guth, the superintendent of the plant, states that the installation of these magnets over the conveyors has saved hundreds of dollars by preventing breakdowns of the crushers and consequent shutdown in the plant.



Lifting magnet suspended over conveyor belt removes scrap iron and steel in materials fed to hammer mill crusher in cement plant.

Portable Motor Testing Table and Motor Record System

I HAVE read with interest from time to time in INDUSTRIAL ENGINEER how operators have made motor tests while the motors are in service and have thought that others may be interested in knowing how our motors are tested and our records are kept.

The accompanying illustrations show several sample "Motor Data" cards which are used for all of our motors, numbering 172, of which 95 are fractional horsepower and 77 range from 1 hp. to 35 hp. Our data cards are indexed according to departments, so that a quick reference may be made.

Our single-phase motors are tested with a voltmeter and ammeter, while for testing the three-phase motors we have constructed a portable table, shown in the accompanying sketches and photograph. The table frame was made of maple and the top and shelf of cedar. It is equipped with three rubber-tired wheels to minimize vibration. A handle was made of ¾-in. pipe and fittings which also serve to hold the flexible connecting cable, while moving the table about. One end of a 6-wire, extra-flexible cable is attached to the terminal board and the other end is connected to three 60-amp., 600-volt empty fuse cartridges. The ferrules are drilled and tapped and the conductors attached with terminals. Adapters were secured which permit connections to be made at any of the 30-, 60- or 100-amp. safety switches at each motor or compensator.

On the test table Fig. 1, switches (A) and (B) transfer the voltage and current readings of the three phases. Switch (C) changes the current reading from direct reading to reading

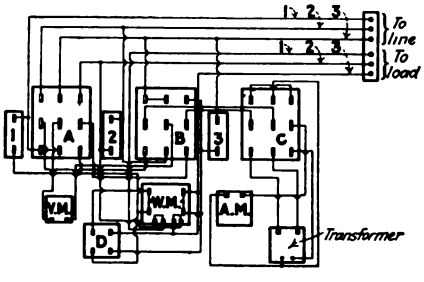


Fig. 1.—Circuit layout for testing table shown in Figs. 2 and 3.

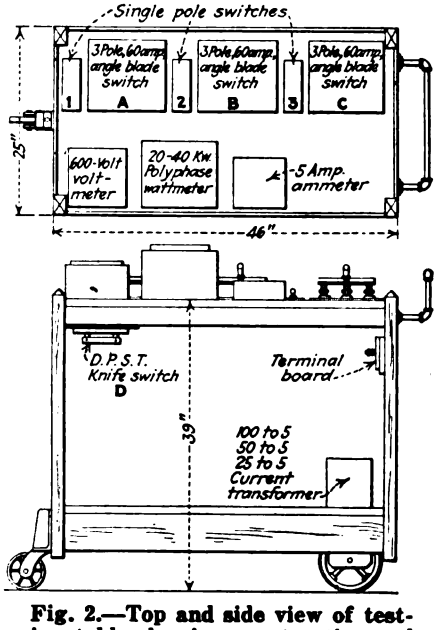


Fig. 2.—Top and side view of testing table showing construction and the equipment it carries.

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with the transformer in circuit or vice versa. Switch (D) is used to short-circuit the current coils in the wattmeter. Switches (1), (2) and (3) are short-circuiting switches in the ammeter circuits.

With (A) and (B) forward, (2) and (3) closed and (1) open, the current in line (1) and the voltage across lines (1) and (2) is indicated. With (1) closed, (A) pushed backward, (B) remaining forward, (3) closed and (2) open, current in line (2) and voltage across lines (2) and (3) are indicated. With (1) and (2) closed, (A) forward, (B) backward, and (3) open, current in line (3) and voltage across lines (1) and (3) are indicated. Switches (1), (2) and (3) must always be kept closed when moving switches (A) or (B).

The efficiency and power factor ratings at various loads, as shown on the cards, are obtained from the motor manufacturer. As opportunity offers "no load" readings are taken and recorded on the test cards. These cards are arranged numerically according to motor number and are kept in the drawer with the "Motor Data" cards. Provision has been made for recording meter record numbers, etc., and it is expected that recording meters will be added to our equipment at some future date. The backs of the test cards have spaces for information regarding the mechanical end of the drive, but this is not used to any extent yet.

These motor data and test cards give all data needed on efficiency, power factor and load conditions, together with observations resulting from inspections.

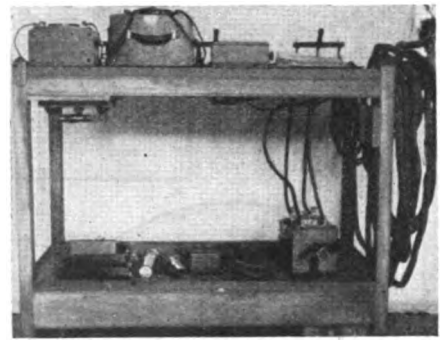


Fig. 3.—Testing table shown in drawings of Fig. 2.

The heavy flexible connecting cable is made up with six flexible conductors connected at one end to the terminal board of the table. The other six ends are connected to empty fuse cartridges. To support the weight of this cable a hook is provided at the fuse cartridge ends so that it can be hooked into the latch of the switch box of the motor being tested, taking the weight off both the connectors and fuse clips.

The card system has been in use less than a year, but already it has proved superior in several ways to our old method of keeping motor records in a book.

Chief Electrician, J. F. MORGAN.
Mercury Mills, Ltd.,
Hamilton, Ont., Canada.

Comment on "Single-Phase Operation of Polyphase Motors"

THE interesting article by Professors Warner and Hall on "Single Phase Operation of Polyphase Motors" in the April, 1925, issue, conveys an impression concerning the protection afforded by fuses on polyphase motors which is incorrect, although it is caused by what is left out, rather than by what is contained in the article.

As these writers point out, there is always a 73 per cent increase in current in the phase still connected after one fuse blows, whether it is a star- or delta-connected motor.

Let us consider the case of a motor taking 110 amp. at full load, protected by 100-amp. fuses properly designed and correctly installed. Suppose the motor is overloaded and the current increased to 130 amp., which causes one of the fuses to blow. The motor continues to run single phase. Obviously, the other two fuses will have been heated almost to the fusing point and the only reason why they did not blow with the first fuse, is because it is impossible to get one fuse to blow at identically the same moment as another. However, on the blowing of the first fuse, the two fuses still remaining in circuit are subjected to a current 73 per cent greater than that which caused the blowing of the first fuse, or a total of 225 amp. A 100-amp. fuse, starting cold, will blow at 225 amp. in 7 sec., but having already been heated as mentioned, the 73 per cent increase of current will cause one or both of the remaining fuses to blow in a second or two. How then is the motor to continue to run single phase?

The argument might be raised that at the exact moment that the first fuse blew, the load was decreased to such an extent that the remaining two fuses would not blow. Such a decrease, however, would have to be almost 50 per cent. If the decrease in load were only one-quarter, there would still be a current of 169 amp. flowing, which would cause the blowing of one or both of the remaining fuses in a few seconds. In other words, to keep both of the remaining fuses in service, there would have to be a drop-off of one-half of the load in less than one second after the fuse blew—a coincidence that can be justifiably labelled a million-to-one shot.

The argument might be raised that a momentary overload or the starting current overload would cause one fuse to blow without blowing the other two fuses. A properly-designed and correctly-installed 100-amp. fuse will carry 120 amp. indefinitely. It will blow at 173 amp. in 21 sec., and yet it

MOTOR DATA

Card No. 1 — Motor No. 1011
Make Gen Elec Co. U.S.A. — Phase 1 — H. P. 1/15
Location Hosiery Looping — Date 1917 — Serial No. 1055700
Class Form 31 — Size — Frame No. — Type SA — Style No. Ind Wound
Rating — hrs. — °C. rise. — Volts 110 — Amperes 1.68 — N.L.S 1500 — F.L.S.
Efficiency | 50% | 75% | 100% | 125% | Power Factor | 50% | 75% | 100% | 125% | Watts at full load
Extras Inverted. 15" Cord.
Repairs July 22/24 new End Ring Assembly installed on rotor

COMPENSATOR

Make
Size — Form — Serial No.
Inspected
Repairs

A

MOTOR TEST CARD

Card No. 2 — Date Oct 24, 1924 — Motor No. 42
Make Can Gen Elec. — Phase 3 — H. P. 15
Location Hosiery Full Fashioned Knitting + Ribbers — Serial No. 30470
Class Form K — Size — Frame 10 — Type I — Style No.
Rating — hrs. — °C rise — Volts 550 — Amperes 16 — N.L.S. 750 — F.L.S. 720
Efficiency | 50% 84.6 | 75% 86 | 100% 86 | 125% 84.7 | Power Factor | 50% 71.5 | 75% 81.8 | 100% 92.2 | 125% 94.5 | Watts Full Load 13000
Extras Inverted — Amperes No Load — Watts No Load
Chart Feed — inches per hour, minute. — Chart No.
Motor:—oily, dirty, clean. Air gap, front end, Top, .015" L. S. .025" R. S. .015" Bottom .015"
Oil in bearings O.K

Time	Volts			Amps.			Watts	H.P.	R.P.M.	Slip	P. F.	Mech. Operating	Input × Eff. = Output
9:20 A.M.	565	565	565	1.1	1.1	1.1	2100	2.81	750	0	39	Rubber Slip 0	281 × 896 = 248 HP
9:25 A.M.	565	565	565	1.3	1.3	1.3	3500	4.7	748	—	55	Rubber Slip 6 = 8040	4.9 × 846 = 3.98 HP
9:30 A.M.	565	565	565	1.5	1.5	1.5	5300	7.1	745	.6%	72	42% Ribbers 35-83	7.1 × 846 = 6 HP
9:35 AM	565	565	565	2.3	2.3	2.3	10000	13.4	740	1.3%	89	42% Ribbers 114 89% Rubber 446	13.4 × 86 = 11.5 HP
	100% Ribbers would take $\frac{(6-3.96)}{.92} = \frac{2.02}{.92} = 4.8$ HP												
	100% Rubber machines would take $\frac{(11.5-6)}{.89} = \frac{5.5}{.89} = 6.2$ HP												
	Total load on motor would be 6.2 + 4.8 + 3.98 = 14.98 HP												

B

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will not blow at a load of 275 amp. in less than 3 sec. This, in all ordinary cases, will take care of the starting current of the motor. Presuming, however, that the starting current is so great as to cause the blowing of one fuse, and realizing that the starting current lasts but a second or two, it is obvious that we would have to have a current of 300 amp. or more. All three fuses are, of course, subjected to this 300-amp. current. One of the fuses blows and at the instant of the blow, the other two fuses are subjected to a current 73 per cent greater, or a total of 519 amp., which would cause the blowing of one or both of these other fuses in less than 1/5 sec. Admitting that the starting current is dropping off at about that time, we cannot, however, get away from the fact that there is 73 per cent increase in current at the exact instant of the blowing of the first fuse and even though the load should be dropping off at that time, such a surge of current after the fuses had been heated up almost to the fusing point would cause the blowing of one or both of the other two fuses practically instantaneously. How then is the motor to continue to run single phase?

It might be argued that the motor is only 69 per cent loaded when one fuse blows. The 73 per cent increase in the remaining phase would give a current of 119.37 amp. which the other two fuses will continue to carry, but how is the first fuse to blow at 69 per cent of full load?

It might be said that motor burn-outs *do* take place because of single phasing of three-phase motors. This is admittedly true, but it is not true that such damage has ever resulted in motors protected by properly-designed and *correctly-installed* fuses. It will be found that whenever such damage has occurred, the fuse which first burned out did so because of poor contact, or in other words, because of heat caused by the resistance of a poor contact.

When fuses are incorrectly installed, that is to say, are subjected to poor contact, a 100-amp. fuse might blow at a load of 69 amp. The 73 per cent increase of current in the remaining phase would give a current of 119.37 amp. which would injure the motor, but would not blow the other two fuses if both of them were correctly installed and were not subjected to poor contact. It is in such cases as this last one that polyphase motors protected by fuses can be damaged, and in such cases only. A polyphase motor protected by properly designed fuses that are correctly installed is really protected. The fuses protecting any one motor should be all of one make and, of course, all of one size to insure such protection.

Poor contact on the fuse may be caused by: (1) poor contact of the fuse in the fuse block clips; (2) improper renewal of the fuse; (3) overloading of the fuse case; (4) loose lugs on the fuse block clips; (5) poor soldering of the connecting wire into the lugs.

All of these things can easily be guarded against in a well-run plant. They should always be guarded against whether fuses, circuit breakers or overload relays are used because the extraneous heating resulting is bound to give trouble no matter what kind of a device is used.

From all of this it is readily apparent that fuses of proper design, correctly installed, will not permit a polyphase motor to run single phase.

Chief Engineer, W. L. LODGE.
Bussman Manufacturing Co.,
St. Louis, Mo.

* * * *

I agree with Mr. Lodge in his statements that with fuses of uniform quality, correctly rated, and properly installed for a given motor, there will be very little danger of single-phase operation, but in actual practice we find that fuses are not uniform, have poor contacts, or are not properly installed and, of course, once in a great while there may be a defective fuse. His summary of fuse installation faults is particularly good.

There is, of course, a possibility of single-phase operation from a ground or single-phase short-circuit which might blow a fuse in a single wire. This ground might not be in the motor and might cause a fuse to blow which would affect several motors.

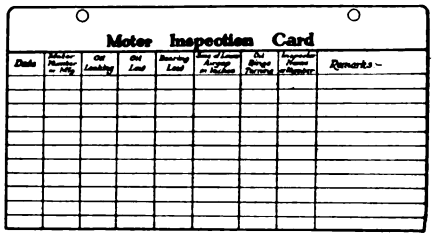
Badly unbalanced voltages are all too frequent. They cause a motor to take unequal line currents and in extreme cases one current might become great enough to blow a fuse while the current in the other lines was not great enough to do so. R. G. WARNER.
Electrical Engineering Department,
Yale University,
New Haven, Conn.

Proper Care of Motor Bearings Essential to Good Service

MANY industrial plants have learned by experience, and at considerable expense, the amount of trouble caused by worn bearings in rotating electrical machinery. In order to cause trouble, bearings need not be worn to such an extent that they allow the rotating element to rub on the stator or poles, as the case may be. Serious trouble has been caused in machines whose rotating element was still free to turn. For instance, if a d. c. generator is not equipped with equalizer connections in the armature winding, large cross currents will be set up in the armature when the bearings wear and allow it to come closer to the fields in the lower half of the frame, than to those in the upper half. This causes one-half of the armature winding to be overloaded, while the other half is underloaded, due to a higher voltage being generated in the lower half of the armature windings than in the upper half, and usually results in poor commutation, indicated by sparking.

The modern induction motor is built with a rather small air gap between the rotor and stator, as compared with the motors of eight or ten years ago. This change in design has been very welcome as the modern induction motor operates at a higher power factor and efficiency than its older brother. Consequently, we must watch the bearings in the up-to-date motor more closely than we did in the older one, for the bearings do not have to wear very much to cause rubbing and probably ruin the motor.

So far we have been considering the 2-bearing machine. In a 3-bearing motor-generator set we have three bearings to watch. Serious trouble has been experienced by some with a set of this kind, due to uneven wear in the bearings. For instance, the center bearing usually has a much larger bearing surface than the two outboard bearings and, therefore, seldom wears as fast. The outboard bearings may wear to such an extent that the rotating member is entirely supported by the center bearing. Each end of the shaft will then tend to "whip" and vibration accompanied by poor commutation is the result on the d. c. end, if there is a d. c. machine on the motor-generator set. It is an easy matter to overlook the bearings when trying to find the cause of this trouble, as the shaft may appear to be bent. Grinding the commutator aggravates the sparking, as flats are ground in it, due to the "whip."


Motor Inspection Card

Date	Motor Number or Mfg.	Oil Leaking	Oil Level	Bearing Load	Amps. of Load or Rating	Oil Rings Turning	Commutator Noise or Sparks	Remarks

Here is a good form of report card covering inspection of bearings and air gaps on motors.

If a machine is allowed to run for any length of time in this condition it will, no doubt, wreck itself as the vibration will eventually break open the risers in the commutator, where the armature leads terminate, causing open circuits or at least high-resistance contacts. The sparking will grow worse until flashing occurs and the machine clears itself from the line by opening the breaker. Further operation without repair is then out of the question.

A system of inspection can be inaugurated in almost any plant, whereby each motor, generator, motor-generator set, or rotary converter is checked for bearing wear weekly or monthly, depending on the conditions.

The accompanying illustration shows an inspection card, which may be used by the motor inspector and kept on file in the chief electrician's office. This card may be modified to suit conditions.

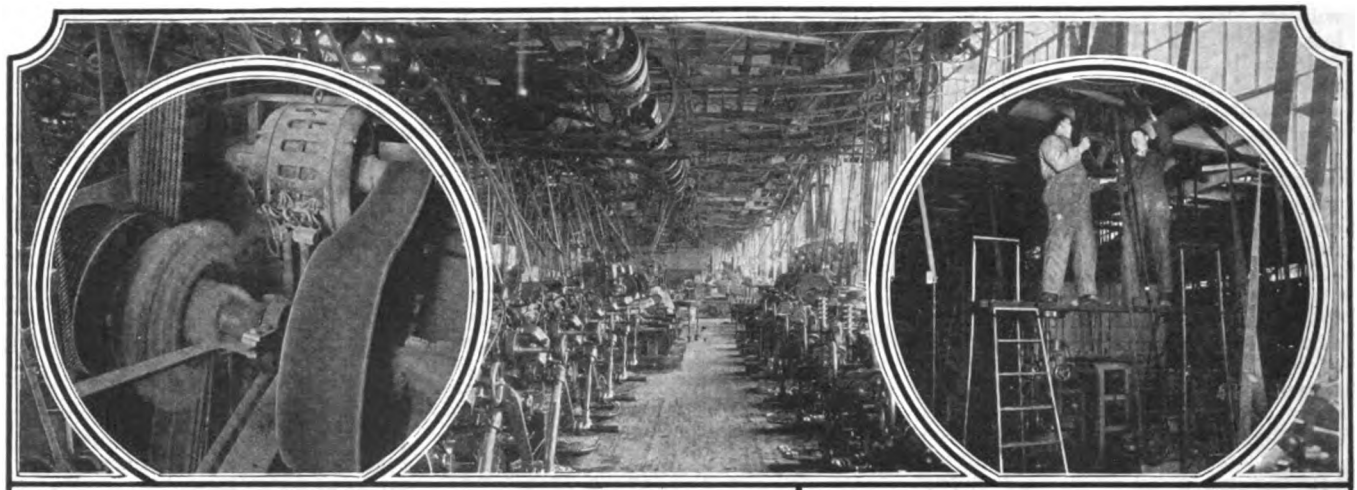
Each inspection should be thorough and the lower air gap should be checked by means of a long feeler gage. In this way serious trouble may be avoided by installing new bearings when the inspection card indicates the necessity.

Machines equipped with ball bearings should be watched in much the same way as those equipped with sleeve bearings, as ball bearings will wear, need inspection, lubrication and cause the same trouble as sleeve bearings.

Always keep a good grade of oil at the proper level in all sleeve bearings, be sure that the oil is changed occasionally, that the oil wells are clean, and you will obtain high efficiency and long life from your bearings.

Service Engineer, GEORGE B. HERON.
Westinghouse Electric & Mfg. Co.,
Columbus, Ohio.

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Mechanical Maintenance of

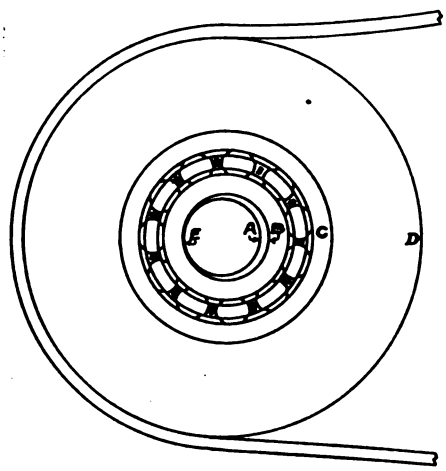
Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Comments on "Why Shafts Peen Under Inner Rings of Ball Bearings"

THE article which appeared under the above heading on page 253 of the May issue of INDUSTRIAL ENGINEER was very interesting. There are, however, some other points that might be mentioned and may be of interest to the readers of INDUSTRIAL ENGINEER.

The "shaft peening" mentioned is more correctly a rolling action. In the accompanying illustration the circle *A* represents the cylindrical shaft. Circle *B* represents the cylindrical inside bore of the inner race of the ball bearing. If the circle *B* is by mistake, made of very slightly greater diameter than *A*, there will be a line represented by *E* where the belt tension or reaction from meshing gears holds these two cylinders in contact. As the shaft rotates, this line moves around both circles *A* and *B*, but as the inner race of the bearing is much harder than the shaft, the surface metal on the shaft will be rolled away from its original position.



This sketch indicates how the shaft may be "peened" if the bore of the inner race is too large.

This action can be completely stopped by making the bore of the bearing slightly less than the shaft diameter, so that there will always be a slight press-fit.

Ball bearings of standard design are today manufactured to allow for the very slight expansion of the inner race that occurs from this press-fit. In this way, no cramping takes place in the bearing when mounted as outlined above.

In larger sizes of bearings, locknuts are added to hold the bearing in position lengthwise of the shaft. This method of mounting ball bearings is standard practice with practically all manufacturers of ball-bearing electric motors at the present time.

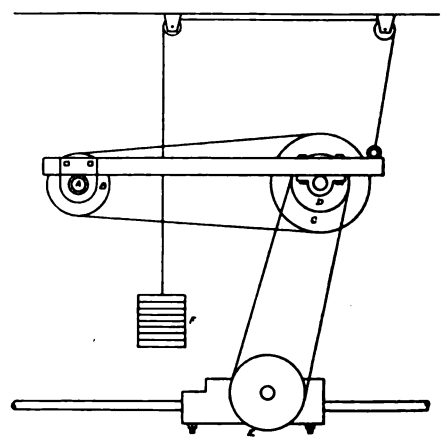
Engineering Dept., R. L. BROWN.
The New Departure Mfg. Co.,
Bristol, Conn.

Changing a Hand-Power Keysetting Machine to Power Drive

ANYONE who has had occasion to keyseat shafting with a portable, hand-power machine, knows that it is not an easy job. Some years ago the writer was on mill construction work and as there was no machine shop within 20 miles, it was proposed to do the keyseating of all shafting with a hand-power machine. The results of the first day were far from satisfactory and plainly showed that some means must be employed to speed up the work, else the shafting could not be installed according to schedule.

In order to speed up the work a swinging frame was devised, as shown in the diagram, and fitted with a jackshaft and pulleys. The handle of the keyseating machine was removed and a wood pulley substituted. The swing-frame was mounted at (B) by means of hollow trunions which surround the lineshaft. The stationary trunions were bolted to horizontal timbers which are not shown, for the sake of clearness. The pulley (B) on the lineshaft drives the large pulley (C) and also a loose pulley, not shown, on the jackshaft at the end of the swinging frame. The small flanged pulley (D) was mounted in an overhanging position on the jackshaft. The pulley (E) need not be flanged, although a flanged pulley might be more satisfactory.

The drive was so laid out that pulley (E) made 100 r.p.m. The milling cutters used on the machine were 2.5 in. in diameter. The counter weight (F) supplied the necessary tension to the belt-driven pulley (E). A snubbing device (not shown) was used to hold the counter weight up and to hold the jackshaft end of the swinging frame down while adjusting the machine on the shafting to be keyseated. When the machine was adjusted the belt was held on both pulleys while the counterweight was gently lowered. The belt from (B) to (C) was slid over from the loose pulley onto (C), thus starting the machine. Next, the vertical feed was turned down until the desired depth of cut was reached. The ver-



This swinging frame made it possible to change a hand-power keyseater for power drive and cut a standard ⅝-in. keyseat in shafting at the rate of 30 in. per hour.

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tical feed screw was then locked in this position and the horizontal feed put into gear. This machine, when power driven, cuts 30 in. per hour of ⅝-in. standard keyseat. This is an increase of about 350 per cent over what a man will cut by hand in 1 hr. and, when an 8-hr. shift is considered, the increase is even greater and the operator is not tired.

During the keyseating operation the shafting was securely fastened down to trestles (bolted to the floor) by means of improvised cast-iron V-blocks and bolts with yokes across the top of the shaft. This was found sufficient to prevent the shaft from turning and the V-blocks on the machine prevented it from turning. This device did the work in an altogether satisfactory manner and was not in the least detrimental to the keyseating machine.

At another time, during repairs, several long keyseats had to be cut; so the handle was removed from a portable machine and a modified coupling made to fit an air motor installed in its place. This arrangement worked well for repairs in a plant where compressed air was available throughout the departments. A large electric drill could also be used to drive the machine and do satisfactory work.

Construction Engineer, W. L. STEVENS.
Smith Robinson Co.,
Vancouver, B. C.

Simple Stuffing Box Without a Packing Gland

THE usual method of constructing stuffing boxes is to make use of a separate gland whereby the packing is pushed lengthwise on the piston rod by screwing down on this gland.

On a pump shaft in a power plant an unusually ingenious departure from the ordinary stuffing box is a box with a single screw, which dispenses with the costly extra parts and avoids removal of the gland for repacking, as is shown in the illustration.

As will be seen, in place of the usual stuffing box, the cylinder head is drawn out into a long section of small diameter and a recess for the packing is grooved inside around the hole through which the rod passes. A drilled hole leads out from this and terminates in a threaded opening for a packing or setscrew.

Wick packing impregnated with tallow and graphite is fed endwise into this opening and encircles the shaft. The setscrew makes the packing tight by compressing it endwise. Segments of packing are placed under the screw as required to compensate for wear. This is a very simple means of keeping packing tight and in this installation has given as satisfactory results as could be wished for.

Washington, D. C. G. A. LUERS.

A Way to Reduce Accident Hazards on Power Transmission Equipment

POWER, no matter how controlled or applied, is still power. Machines and moving parts cannot be instantly stopped and consequently the worker of today is always exposed to the hazards of death or mutilation from the machinery and transmission equipment near which he works. Humanitarian motives generally prompt most employers to use every possible means of reducing working hazards to a minimum but even if this motive were disregarded entirely it is greatly to the employers' interest to eliminate every possible danger in order to avoid the losses incident to expensive lawsuits and interrupted production.

In the past few years much attention has been devoted to the protection of the worker by safety devices of various kinds, covering of exposed moving parts and automatic devices attached to saws, punch presses, drills and other such machines. Open transmission equipment, however, is still found in many plants and is an ever present menace to the lives and limbs of workers. It is to this particular phase of the subject that we shall confine our discussion in this article.

The necessity for transmission equipment is due to the fact that driven machines nearly always operate at a lower speed than the prime mover; therefore a means must be provided to step speeds down to the proper figure. Transmission equipment consists of those devices which are used to deliver power from the prime mover or source of power, to the driven machine. Comprised under this head are belts, pulleys, shafting, chains, sprockets, rope drives, open gearing of various kinds and enclosed speed reducers.

The hazards from open transmission equipment are obviously tremendous. Unguarded belts, pulleys, chains and open gearing traveling at high velocities and driven by power ranging, in some cases, as high as several hundred horsepower, present a menace to workers in the vicinity. When loose clothing, sleeves, belts or the hair of the worker come in contact with these unprotected moving parts serious accidents often result.

Much can be done to reduce hazards on transmission equipment by a careful study of each individual case considered from the standpoint of its potential possibilities for doing injury to workers. Every unprotected rotating part placed in a position where a worker may at some time or other get his fingers, hands, feet, hair or clothing near enough to be caught, is a permanent hazard. The one and only remedy is to cover, guard or enclose the moving parts. This can be done more easily and less expensively in some cases than in others. A simple screen or grating set before the parts will be suitable in some cases, but in others it is necessary to make special sheet metal or cast-iron guards to cover open gearing, moving pulleys, belts and other similar hazards.

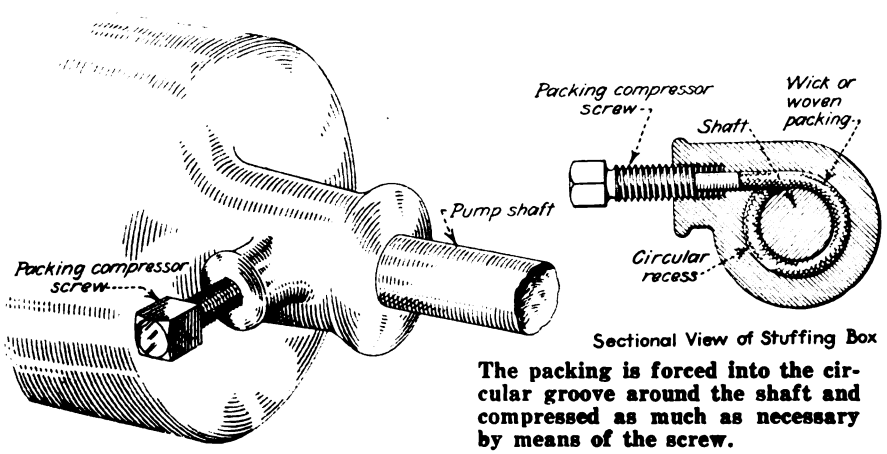
Many plants are using direct drives from motors to manufacturing machines, which eliminate much of the intervening transmission equipment otherwise required. This method is modern, safe and efficient. However, in many cases the speed at which the driven machine is operated is much lower than that at which the standard commercial motors can be secured or operated efficiently, and some kind of reduction unit is necessary.

One of the safest methods of transmitting power and obtaining speed reduction of the desired ratio is through the use of unit enclosed drives known as speed reducers. These machines are somewhat similar to the transmission of an automobile in that they consist of trains of gears enclosed in a suitable case or frame, but they differ in that they are designed to operate at a fixed ratio of reduction instead of a variable ratio as in the case of the automobile transmissions.

The frame resembles that of a motor. The gears are entirely enclosed, operate in oil and there are no exposed moving parts to endanger the workers. The reducing unit is so constructed that power is delivered to one end, called the high-speed end, by the prime mover and the desired speed reduction obtained through the various gears in the machine. The power is then delivered at the reduced speed to the slow-speed shaft which may or may not be concentric with the high-speed shaft. In installing a speed reducer it is only necessary to connect the high-speed shaft through a flexible coupling to the motor or other source of power and connect the low-speed shaft through another flexible coupling to the machine to be driven.

The reduction of hazards on transmission equipment is a subject worthy of the most serious consideration.

Chief Engineer, HARRY C. PETERSON.
Foote Bros. Gear & Machine Co.,
Chicago, Ill.

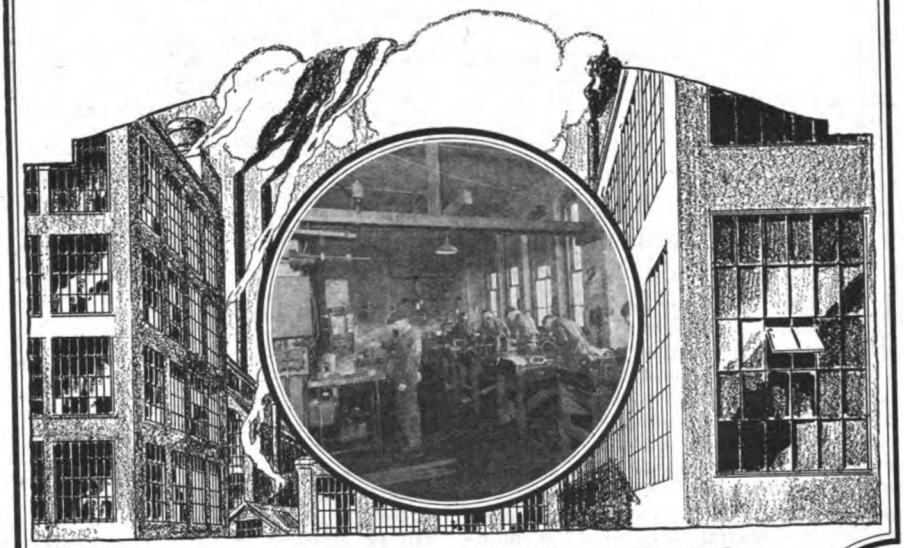


Sectional View of Stuffing Box

The packing is forced into the circular groove around the shaft and compressed as much as necessary by means of the screw.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Quick and Easy Way to Remove Cores of Fans

ON SOME small a. c. fan motors, it is sometimes necessary to remove the core and coils from the frame when making repairs. Many motors have the fan end bracket integral with the frame.

On those motors that have the bracket screws tapped into the core, if the other bracket is loosened and a wedge inserted between it and the frame, one on each side, the core will slide out with the bracket. This is about the only way it can be done quickly and easily on some small fan motors.

The lamp cord from the base of the motor sometimes burns off and in order to repair it efficiently it is necessary to remove the core, and here is where the above mentioned scheme comes in handy.

Of course this method does not apply to motors where the bracket screws are tapped into the frame.

I want to state that I have received much help and many ideas from INDUSTRIAL ENGINEER and if this scheme will be of assistance to other readers I shall be very much pleased. G. H. ENNIS.

The Electric Maintenance Co.,
Providence, R. I.

Easy Method of Making Special Sockets to Fit Odd-Size Nuts or Bolts

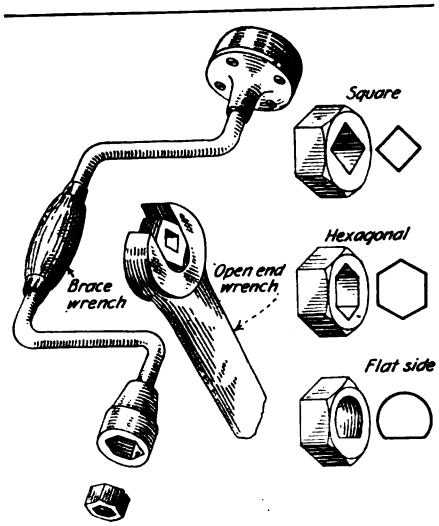
USUALLY it is difficult to obtain sockets for use in connection with small or odd-sized nuts and on bolts with special heads. The brace-handled socket wrench affords the desirable advantage of speed, as the socket is set over the bolt or nut and is turned continuously to remove or tighten without changing the wrench position on each part of the turn.

Special sockets, which can be used as slip sockets in either the solid or removable types of socket wrenches can easily be made from ordinary hexagonal nuts, as is shown in the illustration. This is a practical, time-saving kink which can be used to considerable advantage in almost any repair shop.

Obviously, the nut which is converted into any of the special sockets, should be sufficiently larger than the bolt head on which it is to fit to secure a wall of at least 3-16 in. of metal around the socket after it is machined or filed out to size and shape.

The slip socket may also be used with either the adjustable or open-end wrenches and will be found to protect the bolt head when the bolt is difficult to turn. G. A. LUERS.

Washington, D. C.



With several of these specially-slotted hexagonal nuts a socket wrench may be used on almost any shape or size of nut or bolt head.

Convenient Arrangement for Dipping and Baking Armatures

DIPPING and baking armatures is yielding handsome returns in the form of longer armature life, thereby causing less maintenance and fewer motor outages in many industrial plants and in electric railway systems. This process results in coating and impregnating the armature with a varnish that prevents loosening of the coils and consequent chafing. It also aids in resisting the attacks of oil and moisture on the insulation.

The possibility of pulverizing the insulation on the wires, brought about by vibration of the wires, one against another, or against a nearby coil, is eliminated by virtue of closing up all the space resulting from the drying out of the insulation used in the coil proper and that used as slot insulation when such is used.

The accompanying illustration shows the equipment used by the Harrisburg (Pa.) Railways for its dipping and baking process. A cylindrical tank is set in the floor as shown. This tank is deep enough, and of suitable diameter, to accommodate the largest armature that comes through the repair shop. In practice it is preferable that the inside diameter of the tank be about 12 in. greater than the diameter of the armature. Unless this distance is allowed, dipping a number of armatures in succession will cause a rapid and excessive evaporation of the varnish thinner, thereby resulting in a relatively heavy-bodied varnish requiring the addition of thinner.

When the tank is not in use a cover (not shown in the illustration) is placed over the top; the edge of the cover fits into a lip on the top edge of the tank. This lip is filled with transil oil, making an air-tight seal which greatly diminishes the evaporation of the varnish thinner. A pipe connects to the bottom of the tank so that the varnish may be pumped out when desired. A chain fall is suspended over the tank, as shown in the illustration, to handle the armature during the dipping process.

The procedure in dipping followed by this company is as follows:

An armature which is to be baked is first blown out with air and cleaned as much as possible. It is then mounted in lathe centers and given a benzine bath by turning it slowly in a trough containing benzine. This trough is fitted with a cover which thoroughly encloses the armature while it is in motion and confines the benzine and vapors to the tank. This cuts all the oil and grease that may have worked into the winding and loosens up and washes out the carbon dust and any particles of the old varnish that have cracked off, due to vibration and heat. The washing operation is considered essential because the presence of foreign matter in the form of oil, grease, or carbon dust in the varnish is detrimental. Mineral oil interferes with the drying of the varnish, and carbon dust tends to destroy its insulating qualities.

The armature is then placed in the

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oven and baked so as to thoroughly dry out the winding. After this, the hot armature is dipped into Sterling baking varnish (Sterling Varnish Company, Pittsburgh, Pa.) by means of the chain fall suspended over the dipping tank, as shown in the illustration. The length of time the armature is left in the varnish, or the so-called soaking period, varies with the size and temperature of the armature and the condition of the varnish, and is roughly defined by the statement, "until the bubbling ceases." The armature is then lifted out of the varnish and allowed to drain for a length of time depending upon the size of the armature and the condition of the varnish. Thorough draining of the armature is desirable.

After the excess varnish has been drained off, the armature is placed on the small car shown in the illustration and the car is pushed into the oven. This oven (made by Despatch Manufacturing Company, Minneapolis, Minn.) is equipped with automatic temperature regulation and with electric heating elements that operate at black heat, which gives them a greater length of life than would be the case if they operated at higher temperatures.

An efficient baking oven cannot be constructed from a tight brick enclosure having a few resistors or other heating mediums. This is due to the fact that unless an oven is equipped with proper ventilation, the various functions of the oven during the drying process cannot be successfully carried out.

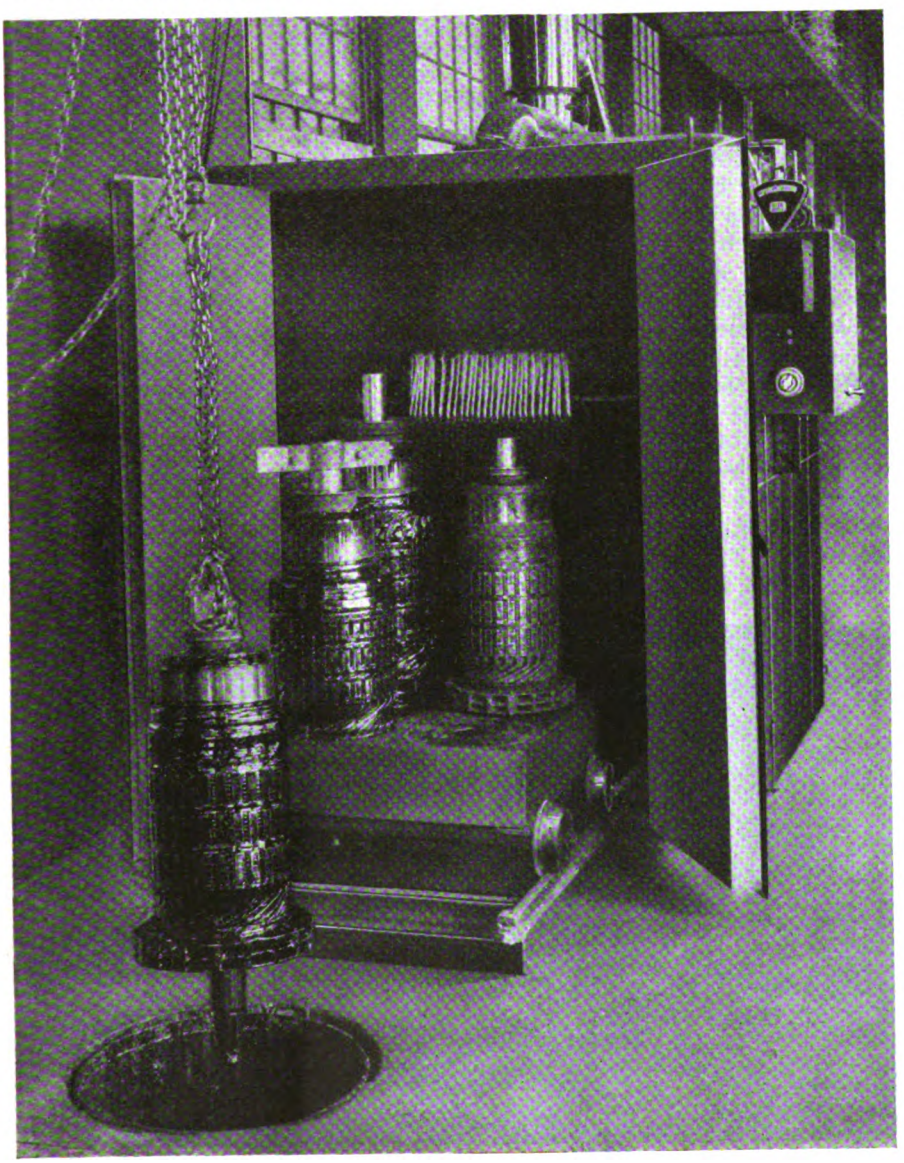
During the baking operation the varnish thinner, which is usually benzine, is driven off as a vapor which settles to the bottom of the oven. Some means of escape for this vapor must be provided in order to secure proper drying of the varnish. Since varnish dries by oxidation of the gums which form its base, after the evaporation of the thinner it is necessary that fresh air with its oxygen content come in contact with the armature in order to obtain proper drying.

During the drying out and the baking processes, it is essential that no part of the oven be at a much higher temperature than the remainder, for in this case there is a possibility of overheating part of the armature and burning the insulation. One of the methods used to prevent this in well-designed ovens is to set up convection currents of hot air so as to give a uniform temperature distribution throughout the oven.

Service Engineer, A. H. KOPPRASCH.
Electric Service Supplies Co.,
Chicago, Ill.

The dipping tank is placed immediately in front of the oven.

A chain fall located over the dipping tank provides a means of handling the armature during the dipping and draining process and also for placing the armature on the small car that carries it into the baking oven.



Laying Down Commutator Leads in Wave-Wound Armatures

MANY times when laying down the commutator leads in a wave-wound armature, trouble is experienced in not having very much room between the core and commutator to lay the wires symmetrically. In most cases, the reason for this is the cotton sleeve which is placed over each conductor for insulating purposes. It is readily seen that where there is only enough room for the conductors with the original covering, and a cotton sleeve is put on each wire also, there will be quite a bunch built up.

To eliminate this bunching, first lay down the wires coming from one of the slots, in the commutator at the proper span. Now, instead of laying down the wires coming from slot No. 2, or the next one to it, skip a slot and then lay those wires in, making sure that the proper number of bars on the commutator are skipped. Proceed this way (skipping a slot) until you have gone once around the armature. The wires laid in may then be bedded into place, taking care not to break the insulation in doing so. When the wires are bedded all right, the remaining wires can be laid down in the commutator. After doing this on a few armatures the winder will find that the first layer of wires will have taken but little space. With a little practice the space taken up by the bottom leads will be no more than two-thirds of that taken up when the leads are laid down symmetrically.

In very large armatures instead of just skipping one slot, skip two each time, bedding the wires as you go along. This will make a three-layer effect which will be of great advantage, for between each layer of wires a layer of 0.005-in. varnished cambric can be placed. This will reduce the danger of short-circuits caused by adjacent wires being jammed together while bedding them down. It also acts as a sponge to absorb the insulating varnish used in dipping and makes a perfectly solid mass, when baked.

Before laying down the top wires in the commutator, it is advisable to force or press a good insulating filling compound in the short space in back of the commutator where the wire insulation is thin. This will help to eliminate short-circuits due to dust particles, such as carbon dust and the light copper dust that is created when sandpapering a commutator.

In laying down the top leads the same procedure can be followed.

Electrical Dept., JAMES H. HANLEY.
Providence Gas Works,
Providence, R. I.

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Removing Fumes, Gases and Vapors

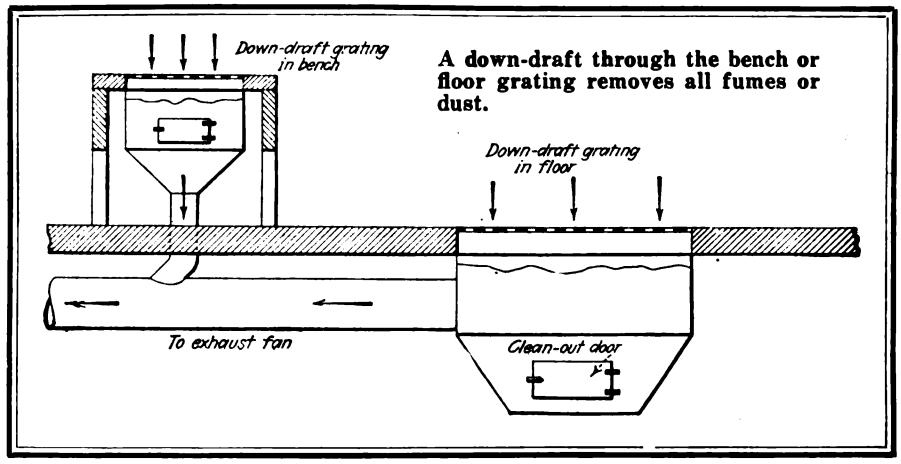
(*Continued from page 280*)

flow should be provided leading to suitably placed slots surrounding the source and connected with a strong suction. Where large storage batteries, for example, are used, one method of providing ventilation is to extend a slot across the front of the tank, just above the surface of the solution, with the other three sides surrounding the tank and raised somewhat to prevent the fumes overflowing anywhere except into the slot. In addition to this, it is usually necessary to provide a small amount of general ventilation at the floor level.

In a room where gasoline or other substances are used which give off fumes heavier than air and which are not easily collected at the source, the use of a system of strong downward ventilation is recommended in which air is admitted near the ceiling and withdrawn at the floor.

An arrangement for removing the fumes arising from articles which have been freshly painted, is to place them upon gratings set in the floor or bench top and connected with an exhaust fan, as shown in the accompanying sketch shown above. Generally, in painting industrial products with an air gun it is necessary to use, in addition, an enclosing hood or booth connected with an exhaust. The work to be painted is placed inside the hood and the vaporized paint or other coating drawn entirely away from the operator. Some of the accompanying illustrations show this type of work.

Foundries produce a mixture of heavy gases and light water vapor which must be disposed of. The most satisfactory method in cases of this kind, particularly with rooms having comparatively low ceilings, is to blow in fresh, warm air near the floor and along the outer wall, and exhaust it through floor registers at the center of the building. This will



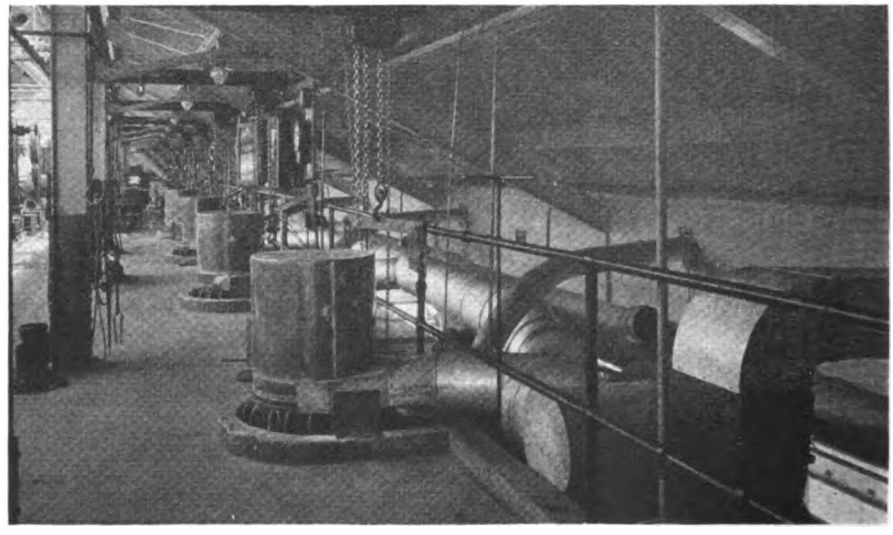
A down-draft through the bench or floor grating removes all fumes or dust.

prevent the formation of fog by absorbing the moisture and carrying out the heavier gases which settle at the floor level. Monitors, where available, help to clear the upper portions of the building of the smoke and steam.

A sufficient volume of air should be supplied to produce four or five changes per hour over a stratum 10 or 12 ft. deep over the entire floor in iron foundries and two or three times that amount in brass foundries.

Paper-machine rooms, dye-houses and the like require the removal of large quantities of moisture to prevent fogging of the atmosphere and dripping upon the product in process of manufacture, thereby bringing down rust or dirt which would damage the product. Where the vapor rises from large, open vats, which cannot be easily covered with hoods, probably the best method of removal is to provide ample, general room ventilation. A generous volume of warm, dry air (at about 70 deg. F.) supplied near the floor and exhausted at the ceiling will take care of most cases. The warm air absorbs the moisture, and as it becomes further heated by mixing with the air of the room, it naturally rises to the roof ventilator and passes out, often without the necessity of an exhaust fan. Some of the accompanying illustrations show a few types of roof ventilators. These work on the principle of an aspirator; that is, as the wind blows past or through the ventilator, it creates a suction which draws the air out of the room.

Propeller or disk fans are frequently placed in windows or wall openings, particularly in multi-story buildings where the vapor is generated several floors below the roof. Also, these same fans may be used in penthouses on the roof and connected to exhaust pipes which are carried down several floors. Where the fumes or vapors are particularly objectionable, or would stain the building it is best to either exhaust them on the roof where they will not blow back into or against the building, or into some kind of separator or washer. Frequently, these separators are placed ahead of the exhaust fan, so as to prevent suspended material clogging up the fan. This procedure is sometimes necessary in connection with ventilators attached



Another installation in which the heavy fumes are exhausted at the floor.

This photograph, like the one shown at the beginning of this article, was taken at the Deepwater Point Dye Works of E. I. du Pont de Nemours & Co. Here individual exhaust casings are placed around autoclaves and removable hoods are placed over the discharge valves and are exhausted through the rectangular ducts shown at the right and left top. Fresh air supply ducts are also placed above in the center.

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to painting booths and in some chemical processes.

When the vapor is formed within a limited area, it is usually best to provide hoods connected with an exhaust fan, and thus prevent its escape into the room. These hoods are placed as close to the work as possible without interfering with the operations performed. In some cases the work is totally enclosed so that no fumes or gases can escape into the room. This, too, is usually done in connection with chemical processes, or where the fumes or products are inflammable or explosive.

Fans of the ordinary steel plate or multi-blade type are commonly used for handling fumes and vapor where the resistance to be overcome is low and the volume of air handled is comparatively large. Fans of this type are ordinarily designed to operate under static pressure (or suction) up to 5 in. of water which exceeds the requirements for practically all usual work of this kind.

If for any reason, greater resistances are to be overcome, high-pressure exhausters of special design may be employed which are capable of maintaining a suction of 10 or 12 in. of water at the fan inlet. The special feature of an exhauster of this kind is a narrow fanwheel operated at a high velocity. When the fan is to handle air containing acid fumes or other corrosive gases, it must be of special construction or otherwise protected to prevent injury. When the moisture does not contain a heavy proportion of corrosive fumes, it is often sufficient to paint the fan and casing with asphaltum or other protective material, but if the fumes are highly concentrated, it is often necessary to coat the exposed steel parts with lead or make them of copper, Monel metal, Duriron, Alcumite or other material not affected by the particular substance to be handled.

In some cases the problem consists in removing an objectionable odor. One example of this is the problem of providing fresh air for the offices of the meat packing companies at Chicago, Ill. Here the entire atmosphere for some distance from the office is contaminated by the fertilizer and some of the other by-products of this industry. The air contains both dust and an objectionable odor. The dust can be filtered out, but the odor still remains.

This problem is solved by sealing the double windows in the office buildings tightly, so that outside air cannot get in, and installing a forced air circulation system inside. The air is washed to remove the odor and dust, heated and circulated throughout the building, which is maintained at practically a constant temperature and humidity throughout the year. It is seldom necessary to go to these lengths. However, the subject of air washing will be taken up at greater length in the discussion of dust removal, as frequently, the dust in the air is more objectionable than the fumes, which are removed with the dust.

Other articles which will appear in later issues will discuss the removal of dust and also the removal or transference of heavier by-products, such as shavings, as well as light materials, such as cotton, wool and so on, which are also often moved pneumatically.

Rotary Operated as Condenser

(*Continued from page 264*)

leading, this commutating difficulty, even if serious, need not be allowed to prevent the desired use of the machine. In such a case, it is desirable to raise the running brushes to save brush friction losses and commutator wear. There is no need to leave these brushes in contact with the commutator, for no direct-current load is to be carried. All rotaries arranged for starting from the alterating-current side are equipped with brush-lifting devices which make this easy. The few (usually two) thin, pilot brushes which excite the field during starting will answer equally well for the same purpose during synchronous condenser operation. Their thinness greatly improves commutation and often eliminates the commutation difficulty. If even these starting brushes spark there is another alternative. If the rotary that is to be operated as a synchronous condenser is a spare, and another rotary is ordinarily in operation, it is usually a simple matter to arrange for exciting the spare rotary from the direct-current bus fed by the rotary that is in operation. Many switchboards are normally arranged for such bus excitation because it is the simplest manner of assuring correct direct-current polarity when paralleling a second machine with a machine in operation. Where bus excitation is not already installed, it is a simple matter to arrange for it by putting in a small knife switch. This makes it possible to raise all brushes, starting brushes included, and eliminate all commutation difficulty whatsoever.

How Service Conditions Affect Belts

(*Continued from page 270*)

less than with the tight side below because the sag of the loose side tends to become greater as the center distance is increased, thus reducing the arc of contact when the loose side is below and partly canceling the effect of the increased weight of belt between the pulleys. Therefore, the greatest difference in transmission capacity between operating the tight side above and operating it below occurs at the longest centers and gradually becomes less with short centers until at 4 ft. there is practically no difference in the power transmitted.

Careful examination of the data taken on pulleys of different diameters, revealed that the arc of contact does not seem to have as much effect on transmission capacity as the pulley diameter, and that the effect of reducing the size of one pulley is about the same as though both were reduced. Thus, a 12-in. pulley driving a 36-in. pulley will give about the same capacity as though it were driving another 12-in. pulley. It is likely that when one pulley is smaller than the other most of the slip takes place on this pulley instead of being divided between the two, thus increasing the co-efficient of friction between the belt and the small pulley, which tends to compensate for the loss in the arc of contact on this pulley. The diameter of the small pulley, or their common diameter if they are the same size, seems to be the determining factor in the power transmitted by the belt.

With this principle in mind, the curve in Fig. 8, marked "Small Pulley Size," was drawn. It takes care of the three factors, arc of contact, pulley diameter and pulley ratio and simplifies the computations, as compared with previously-used methods of allowing for these factors.

In addition, if the diameter of the smaller pulley is the determining factor, then for big drives the same thing should hold true. Thus, a 3-ft.

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pulley driving an 18-ft. pulley should transmit the same power as though it were driving another 3-ft. pulley, or any size between 3 and 18 ft., at the same center distance. Data from these tests indicate that increasing the pulley diameters beyond 36 in. does not give much increase in capacity; so if both pulleys are larger than this the correction factor would be 1.00, leaving only center distance to be allowed for. The correction also becomes 1.00 for center distances over 25 ft., when the tight side is below, although there is probably some increase in capacity for greater center distances.

Slate as Switchboard Material

(*Continued from page 275*)

voltmeter; *Vx*, drop across the unknown resistance; and *Rv*, the resistance of the voltmeter in ohms.

In these equations *Rx* is the value sought. The resistance, *Rv*, of the voltmeter can be read from the instrument and is, therefore, known. *Vx* can be ascertained by subtracting from the e.m.f., *E*, impressed across the voltmeter and the unknown resistance in series, the voltage drop across the voltmeter. This gives us Vx=E—Vv. Then substituting this value for the *Vx* in the second equation, the resulting formula is Rx (in ohms)=Rv(E—Vv)÷Vv.

As an example, referring to Fig. 1 assume that:

E=Line voltage measured with connection indicated by dotted line =109 volts.

Vx=Voltage with dotted connection removed=1.3 volts.

Rv=Resistance of voltmeter= 20,000 ohms.

Rx=Resistance of insulation to be determined.

Substituting in the formula given above, Rx=20,000 (109—1.3)÷1.3= 1,656.91 ohms.

One method of determining whether any fault in the slate is due to dampness or a metallic conducting substance is to disconnect the busbar system from the individual switches and fuses and then test either from switch plate to switch plate or from switch plate to ground, using the voltmeter or high-voltage test. In this way spots which have a very low resistance can be located.

If leakage occurs only in individual circuits it is probable that metallic veins are present, whereas if the panel shows poor insulation all over it may be safely assumed that the slate has reabsorbed sufficient moisture to cause whatever leakage exists. By allowing sufficient time for the slate to dry, and providing proper ventilation this leakage usually stops.

In those cases where the slate is mounted in especially damp locations or directly against masonry walls, the exposed surface should have a coat of black marine finish as described previously, and the back should have a coat of any kind of varnish which will close the pores. These simple, inexpensive precautions should eliminate all leakage due to reabsorption of moisture.

Switchboard Materials Must Be Properly Installed

Upon the method of securing switchboard materials to the supporting framework or walls, rigidly fastened and ready for the electrical apparatus or machinery, depends in great measure the success of the entire installation. It is not enough merely to screw or bolt the various portions together; they must be so proportioned and arranged that constant use, varying temperatures and the shocks and vibrations incident to their use will not affect them. Furthermore, if installed in damp locations, or where there is a lack of circulation of air, the precautionary measures elsewhere described should be used. It has been found that most of the cases of trouble occurring after the apparatus is installed and in service are actually due to improper mounting of the panels, whether of slate or of other similar switchboard material, rather than to any other cause.

The very first step in the mounting of slate, is to make the diameter of the holes for the studs which are used to hold the panel in place from 15 per cent to 20 per cent larger than the diameter of the bolts themselves, as shown in Fig. 2.

Since it is practically impossible to make either a pipe framework with its malleable fittings or an angle-iron frame so accurate that all points of contact conform to a true plane surface, some means must be provided to compensate for these differences in order that neither the slate panel nor the framework will be distorted when the structure is tightened up. The best way to accomplish this, as is already a standard practice with most of the switchboard builders, is to insert between the back of the panel and the surface of the angle iron or the malleable pipe fittings a washer of suitable dimensions of some compressible material as rubber, fibre, leather or tough paper, as shown in Fig. 2 and some of the other illustrations.

The weight of the slate should not rest on the screws, bolts, cap screws or studs used for holding the slate in place on the framework. In the case of a complete switchboard assembly, a channel-iron base should be provided, such as shown in Fig. 3. A completely erected switchboard is shown in Fig. 4. If the switchboard assembly does not reach to the floor a piece of angle iron should be mounted on the framework on which the slate slabs rest.

When extreme conditions are encountered, in which the entire structure is subjected to a considerable amount of vibration, shock or jar, it might be of advantage to insert between either channel-iron or angle-iron base a strip of packing material such as ordinary rubber packing, in order to provide a cushion effect. With the weight of heavy busbar structures and the stresses caused by oil circuit breakers or compensators careful cushioning of the entire switchboard will greatly reduce destructive vibration upon the highly sensitive meters mounted on the board. This precaution will also prolong to quite an extent the life of these expensive and essential instruments.

It will also be found of advantage to allow plenty of clearance in the holes drilled for switch or circuit breaker studs to be used in the mounting of any other instrument or apparatus. It will result in ease of alignment and less cost for mounting, will prevent stresses that may fracture parts of the panel and at the same time reduce the destructive thermal action of momentary overloads on any particular circuit.

Good circuit breakers or good knife switches have been known to be spoiled before being actually brought into operation by forcing them into holes spaced so that they would bind the parts, throwing them out of alignment and thereby preventing proper operation. The same applies also in the mounting of electrical instruments. In the case of starting compensators, oil switches, and circuit breakers, the slate will be able to withstand vibration and

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impacts much better if the studs have plenty of clearance, as thereby either the washer or the contact surface of the apparatus will evenly distribute the pressure.

The U. S. Navy specifications are severe in regard to the mounting of switchboard materials. They were primarily designed to protect the board against the terrific shock of modern gunfire. These specifications give a most excellent method for protecting installations exposed to severe vibration, shocks or jars, and are recommended by many authorities for that purpose. Extracts of the essential portion are as follows:

Panels shall be secured to an approved frame of angle iron. Two thicknesses of ⅛-in. rubber packing shall be inserted between the bottom of panels and the horizontal angle-iron support, and one thickness of similar packing shall be inserted between back of panels and vertical members of frame.

Switchboards shall be mounted on frames of angle iron having dimensions not less than 2¼ in. by 1½ in. by ⅜ in.

The importance of properly providing for the mounting of slate and for the assembling of the angle iron or pipe framework should be strongly emphasized. The construction of the framework is, therefore, of especial interest. Some of the accompanying illustrations show three different types of assembly. For example, in Fig. 5 is shown an angle-iron switchboard frame; in Fig. 6*A* a benchboard frame; and in Fig. 6*B* a pipe frame switchboard assembly. Each of these is typical of good construction and shows suggested methods which may safely be followed.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Insulation Resistance Testing Apparatus—Catalog 1075, entitled "Megger and Bridge-Megger Testing Sets," not only describes the apparatus but gives a discussion on insulation and the measurement of its resistance. In addition, several pages are devoted to general directions for using these testing sets. This is followed by special directions for various insulation resistance tests, and for megger testing.—James B. Biddle, 1211-1213 Arch St., Philadelphia, Pa.

Junction Box Condulets—Folder 21 shows three types of junction box condulets with removable hub plate which provides for additions without disturbing the existing conduits or interrupting the service.—Crouse-Hinds Co., Syracuse, N. Y.

Spur Gears—A folder bearing the title "Gear Teeth That Are Accurate" describes the advantages of using heat-treated spur gears with ground teeth and indicates the sizes in which they may be purchased.—Foote Bros. Gear & Machine Co., 236-246 N. Curtis St., Chicago, Ill.

Belt Fasteners—Catalog 717 describes the line of Bristol patent steel belt lacing which consists of steel prongs with wedge-shaped points, similar to staples. These points are driven across the joint of the belt and the points clinched. This catalog lists the various sizes of steel lacings and shows the sizes of belts to be used with each. Patent steel belt plates are likewise listed, together with the sizes of belt they are to be used on. Space is also given to wire belt lacing, belt hooks and also to a special safety set screw.—The Bristol Co., Waterbury, Conn.

Enclosed Fuses, Fuse Cut-Out Bases and Fuse Boxes—Catalog 60 entitled "Noark Enclosed Fuses" devotes 64 pages to a discussion, description, specifications and prices of the "Noark" renewable and non-renewable fuses with ferrule or knife blade contact, as well as special types, non-indicating fuses, high-tension fuses, service and subway junction boxes and other protective devices.—The Johns-Pratt Co., Hartford, Conn.

Combined Megohmeter and Voltmeter—Bulletin 135 describes the portable "2 in 1" megohmeter which indicates both resistance and voltage and may be used to measure the insulation resistance of electrical equipment during and after the process of manufacture or assembly.—Herman H. Sticht & Co., 21 Park Row, New York City.

Electric Heat—A bulletin bearing the above title is issued frequently by the Department of Publicity of this company, and shows a variety of applications of electric heat in industrial plants. This will be mailed regularly upon request.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Flexible Couplings—Bulletin 37 describes the Franks flexible coupling which consists of flanges connected by flexible pins. This booklet shows a large number of installations, gives dimensions of units of different capacities, directions for installing, information for users, and several pages of information about direct-connected installations. This equipment is made in heavy-duty, high-speed, marine and various special types as well as a light pressed-steel unit for fractional horsepower motors.—Smith & Serrell, 26 Washington Place, Newark, N. J.

Copper Covered Steel Wire—A binder of engineering data shows the method of making the copper weld by the molten welding process and also contains a number of sheets giving engineering data, specifications for purchasing, inspection and testing as well as charts and tables. This information covers solid and stranded bond wires, ground rods, guy, messenger and strand wire, police and fire alarm circuits, signal and telephone line wires, overhead ground lines, sag and tension charts, wire and loading tables, as well as general and comparative wire tables, and so on.—Copperweld Steel Co., Braddock Post Office, Rankin, Pa.

Electrical Porcelain—A folder illustrates, prices and describes Federal solid, telephone, nail and split knobs as well as cleats and porcelain tubes.—The Federal Porcelain Co., Cary, Ohio.

Polyphase Power Transformers—Bulletin 2040 gives cutaway views showing the construction of several of these high-tension transformer units.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Ball Bearings—A folder announces that a complete stock of Chapman ball bearings for power transmission on lineshafts, pillow blocks, and for loose pulleys, is carried by this company.—W. A. Jones Foundry & Machine Co., 4430 W. Roosevelt Rd., Chicago, Ill.

Fifty Years in Insulation—In a handsomely illustrated folder entitled, "Our Fiftieth Year," this company reviews briefly the progress of their concern in the manufacture of insulating equipment.—The R. Thomas & Sons Co., East Liverpool, Ohio.

Automatic Across the Line Starters—A new catalog describes the Sundh automatic a. c. starter of the across-the-line type with no-voltage release or low-voltage protection and also inverse time limit overload protection. Six different types of apparatus are described and listed.—Sundh Electric Co., Inc., Newark, N. J.

Fans and Blowers—Bulletin 1801 is a 72-page catalog of American "Sirocco" fans and blowers and gives capacities and specifications for the wide variety of units and different sizes.—American Blower Company, Detroit, Mich.

Commercial Roller Bearings—A catalog bearing the above title describes the construction of and lists Bond commercial roller bearings with or without split outer races for use in machinery of various kinds.—Bond Foundry & Machine Co., Manheim, Lancaster Co., Pa.

Spray Gun for Furnace Maintenance—Descriptive literature shows the construction and operation of the Quigley refractory gun for use in relining, patching or surfacing furnace walls. The refractory material is shot against the wall by air pressure. It is stated that this gun may also be used for rough whitewashing,

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spraying paint or handling plastic mixtures such as stucco.—Quigley Furnace Specialties Co., 26 Cortlandt St., New York City.

Speed Transformer—Bulletin 105 describes the Poole Type H speed transformer, in which the shafts of the two herringbone gears are in a horizontal plane. Bulletin 106 describes the Type K speed transformer for increasing or decreasing speed, in which the shafts of the herringbone gears are in the vertical plane with the pinion shaft at the top.—The Poole Engineering & Machine Co., Baltimore, Md.

Double-Helical Gear Drives—Bulletin B discusses the types and methods of manufacture of double-helical gear drives with cut teeth, shows how they are made and gives a large number of illustrations of installations of Mesta speed reduction units and gear drives. Mesta flexible couplings are also illustrated.—Mesta Machine Co., P. O. Box 1124, Pittsburgh, Pa.

Direct-Current Automatic Starter—Bulletin 7107-C describes a new, direct-current automatic starter with time limit acceleration and the resistance mounted on the front of the panel. These starters are primarily intended for d. c. motors from ½ to 5 hp. Bulletin 7100-C describes the classes 7110, 7120 and 7130 direct-current automatic starters.—Industrial Controller Co., Milwaukee, Wis.

Jack-Type Disconnecting Switches—Circular 68455, Class 11, illustrates and describes the CR-1923, A-1 alternating-current, jack-type, disconnecting switches for single-phase, two-phase, or three- or four-wire, three-phase circuits. These switches provide convenient means for easily disconnecting motors and control equipment from the line for the purpose of inspecting or working on the equipment in safety.—General Electric Co., Schenectady, N. Y.

Automatic Starting Compensators—Bulletin 68456, Class 11, illustrates and describes the CR-7051-J1 automatic starting compensator for squirrel-cage induction motors, 25 to 60 cycle, two or three phase, with a maximum capacity of 15 hp. in the 25-cycle and 25 to 50 hp. in the 50- and 60-cycle types. This motor starter is for remote control of constant speed induction motors up to 600 volts.—General Electric Co., Schenectady, N. Y.

Materials-Handling Equipment—Bulletin 101 describes the Models F and G Barrett hand-lift trucks, and gives their construction and advantages. Bulletin 103 describes "Steeleg" platforms. Bulletin 300 describes the construction and operation and shows a large number of applications of the Barrett portable elevator for stacking material.—Barrett-Cravens Co., 1328 W. Monroe St., Chicago, Ill.

Safety Switches—Publication F-4648 entitled, "The A B C of Safety Switches," gives information on safety switches which is demanded by the specifications of the National Code and state and municipal ordinances. This booklet also deals with the many uses of safety switches and the principles of their operation. Among the points discussed are: A description of safety switches and their use; why switch parts burn out and the remedy; how to tell the proper type of switch for every job; the purpose and use of safety motor starters and how to tell the proper type for every job; what thermal cut-outs are and why they are used.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Water-Proof Paint for Wet Surfaces—A folder describes Mastertex which is a water-proof cement paint that can be applied directly to a wet, dripping wall such as the interior surface of a wet basement or the outside of rain-soaked stucco or concrete work. This paint may be obtained in several permanent colors.—The Master Builders Company, Cleveland, Ohio.

Charging Hoist for Foundry Cupolas—Bulletin 217 shows the construction and method of operation of the Roots charging hoist in foundries. This consists of a cage-operated monorail hoist with an extension arm carrying a bucket or magnet which is inserted into the cupola and the load dropped.—The P. H. & F. M. Roots Co., Connersville, Ind.

Squirrel-Cage Motor—Bulletin 100 describes the Linzee squirrel-cage, 40-deg. induction motor for two- and three-phase, constant-speed, continuous duty, which is provided with either ball or sleeve bearings. Special design, construction and operating features are given. This organization is successor to the Phoenix Electric Co.—The Linzee Electric Motor Co., Mansfield, Ohio.

Slack-Belt Idler—A folder describes the ball-bearing belt-slacker, which is a special belt idler that may be attached to any motor and is claimed to increase belt wrap without making high belt tension. This folder contains a useful table giving the approximate belt speeds in ft. per min. for two to fourteen-pole alternating-current motors with any diameter of pulley.—Harry M. Perry, 702 No. Main St., Los Angeles, Calif.

Coal Meter—Bailey Meter Co., 2015 E. Forty-sixth St., Cleveland, Ohio—Bulletin 221 describes the construction and operation and shows a number of installations of Bailey meters for coal and other granular materials. This meter consists of a spiral vane which is placed in the stoker feed pipe or other similar pipe and is rotated by the passing of the coal.

Conduit Fixtures—Crouse-Hinds Co., Syracuse, N. Y.—Bulletin 2062 describes and lists the Mogul series of conduit fixtures which meets the demand for units with an unusually long cover opening so as to avoid kinking heavy wire or cables when pulling or feeding through a conduit system.

Grounding Devices—Groundulet Co., 83 Park Place, Newark, N. J.—Circular 60 lists the various sizes and prices of different Groundit bushings, soldering studs and ground studs for switchboxes as well as the Groundulets for making quick and serviceable grounds in electrical distribution systems.

Remote Control for Circuit Breakers—Condit Electrical Mfg. Co., South Boston, Mass.—Bulletin 456 describes the electrically operated mechanism for automatic closing and reclosing of oil switches and circuit breakers by direct or alternating current. Bulletins 454 and 455 describe the Types D-13B and F-11 oil switches and circuit breakers for manual or electrical remote control in single unit construction and in truck-type units mechanically interlocked.

Brass Data Book—Bridgeport Data Book 16 devotes 48 pages largely to tabular material which gives dimensions, standards and other data on the copper and other alloy rods, tubes, bars and sheet made by this company. This is an interesting book in pocket size for anyone who must purchase material of this sort.—Bridgeport Brass Co., Bridgeport, Conn.

Portable Woodworking Machines—J. D. Wallace and Co., 134 South California Ave., Chicago, Ill.—Catalog 402 D contains a description of the complete line of Wallace portable machines for working wood. These consist of band saws, universal and plain circular saws, jointers, planers, lathes, all with direct motor drives, and a glue pot. All of these devices may be operated on an electric light or power circuit.

Non-Metallic Gears—General Electric Co., Schenectady, N. Y.—Circular 68711 entitled, "Textolite Gears," describes the construction and use of these gears which are made of Textolite, a special composition on a fiber base.

High-Frequency Oscillators—Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.—Bulletin 984 describes the "Vreeland Oscillator" and other devices for producing high-frequency alternating current such as may be required in many of the measurements of inductance, capacity and resistance where it is desirable to determine these quantities at frequencies higher than the usual 60 cycles.

Line Hardware and Equipment—Line Material Co., South Milwaukee, Wis.—A bulletin entitled, "The Line," issued monthly, describes the use and application of a variety of line material equipment.

Steel Industrial Furniture—The Toledo Metal Furniture Co., Toledo, Ohio—Price list 625 gives quotations on steel equipment for office, factory, industrial cafeteria and other uses. This consists of tables and stands for offices, vaults, trucks, portable tool trays and trucks, PosturChair, stools and other metal furniture for industrial plants.

Load Indicators—A bulletin contains a complete description and many illustrations of the various types of Cory load and period indicators, manual controls and totalizing wattmeter-operated automatic control. This equipment provides a simple means of indicating at all times in the boiler room firing aisle, the exact electrical load being delivered by the station and insures a more even and economical firing of boilers.—Chas. Cory & Sons, Inc.—183-7 Varick St., New York.

Conduit Fixtures—Crouse-Hinds Co., Syracuse, N. Y.—Folder 13 and bulletin 2056 describes the line of connectors of the CG Series with rubber bushings or split-lead sleeves for connecting round flexible cord and cable, or armored or other round cable.

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INDUSTRIAL ENGINEER

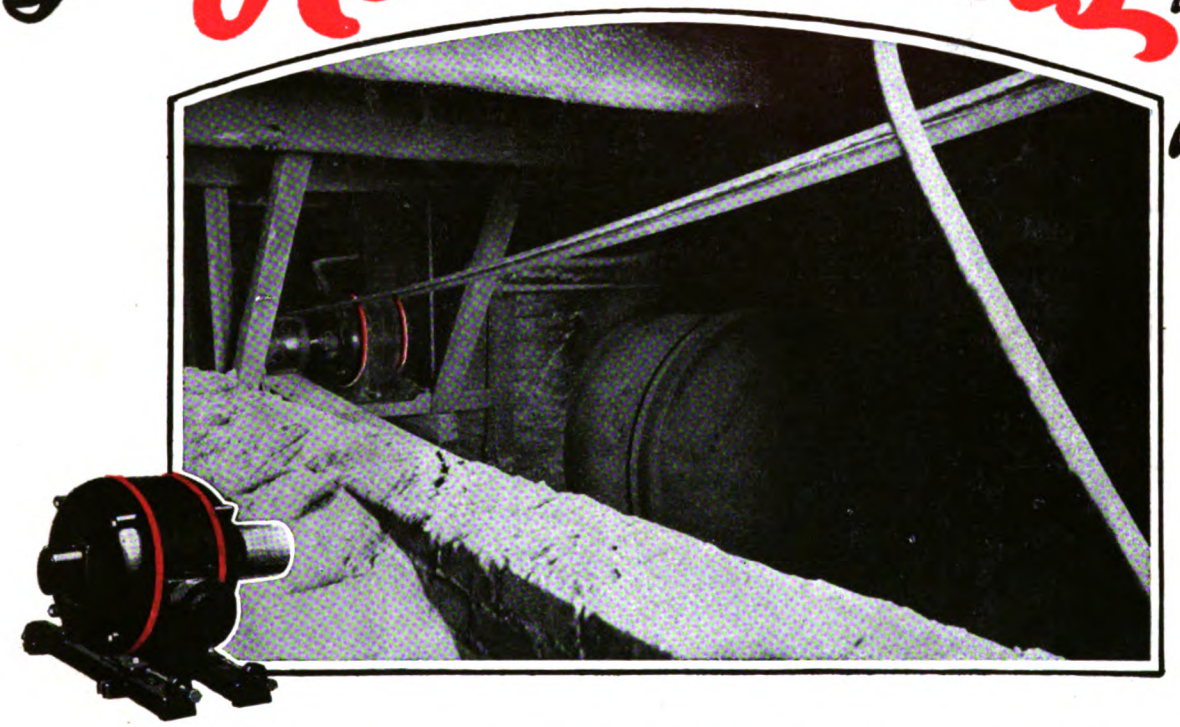
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

July, 1925

McGraw-Hill Co., Inc. Chicago, Ill.

Give Red Bands your hard jobs



"Red Bands Stand Up Exceedingly Well in Magnesite Dust and Magnesium Chloride Fumes,"

writes Mr. O. Peterson of the National Kellastone Co., Chicago, Ill., "In our stucco, flooring and plaster mill at Waukegan, Illinois, the Howell Motors are operating under very severe conditions. Magnesite dust and magnesium chloride fumes prevail throughout the mill making it absolutely necessary to wash out motors with gasoline every ten days or two weeks in order to assure efficient operation. Under these adverse conditions the Howell Motors are standing up exceedingly well.

"At present we have 16 Howell Red Band Electric Motors ranging from 1 to 20 Horse Power in daily operation.

"We are the largest producers of oxychloride products in the country and it is necessary that we have motors that are dependable. We have no hesitancy in recommending Howell Motors."

Howell Red Band Motors are made in all types and sizes from ½ H. P. to 100 H. P. Sales and Service blankets the nation. Catalog on request.

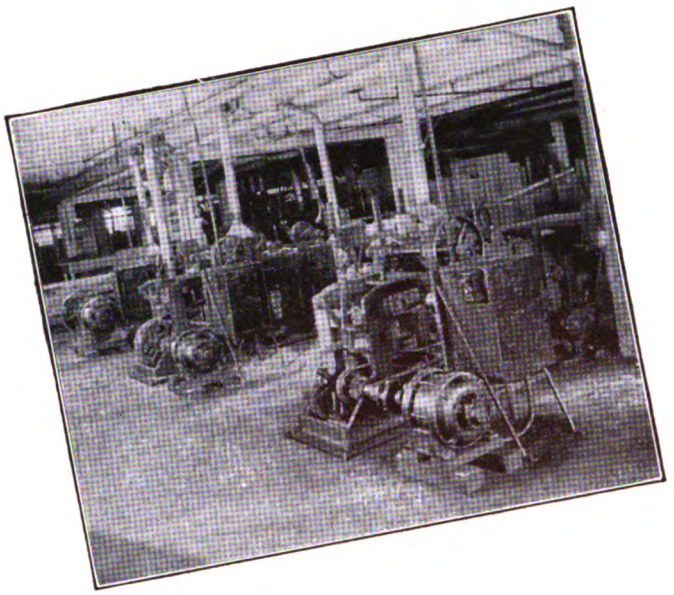
Howell Electric Motors Company
Howell, Michigan

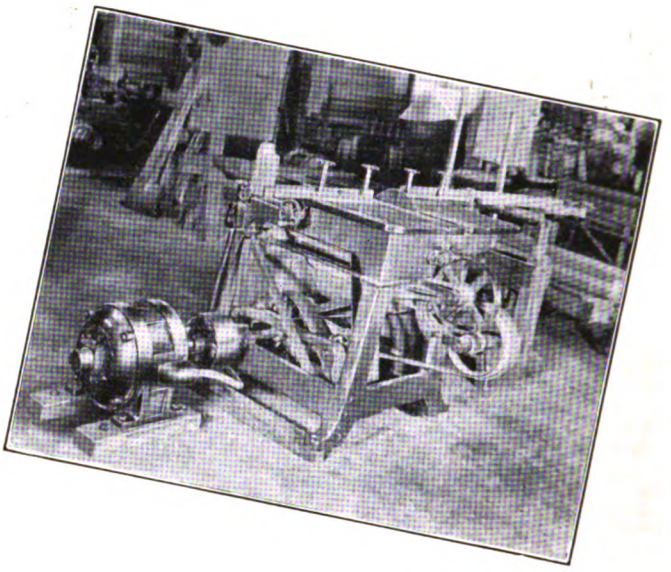
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Howell RED BAND ELECTRIC Motors

Make Good On The Hard Jobs

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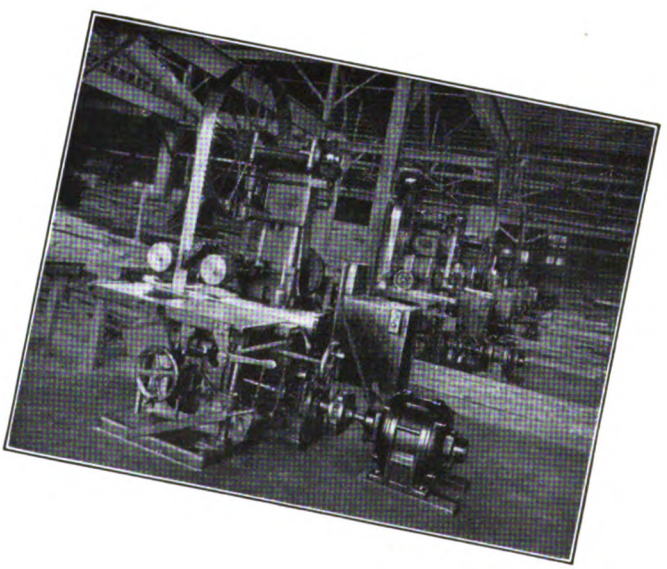
Allis-Chalmers Type "AR" Induction Motors in the Wood-working Industry

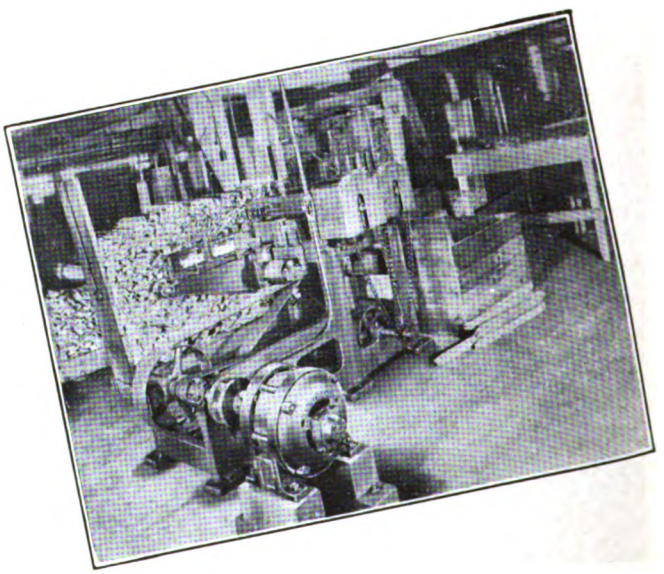
The Type "AR" Squirrel Cage Induction Motor is used in a great number of wood-working plants throughout the country.

The all-steel frame construction makes it a very rigid and strong motor, eleminating breaking of feet.

Free and open ventilating passages provide good ventilation and make the motor accessible for cleaning.

Large rigid shafts with ample size bearings reduce bearing troubles to a minimum.





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Volume 83

INDUSTRIAL ENGINEER

Number 7

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
JAMES H. McGRAW, *President*
JAMES H. McGRAW, JR., *Vice-Pres.-Treas.*

Chicago, July, 1925

G. A. VAN BRUNT, *Managing Editor*

Pioneering With Motor Drives—

A Little History and a Record of Motor Performance That Will Be Hard to Beat

HUNDREDS and even thousands of small motors in a single textile mill driving looms and spinning frames now create little comment.

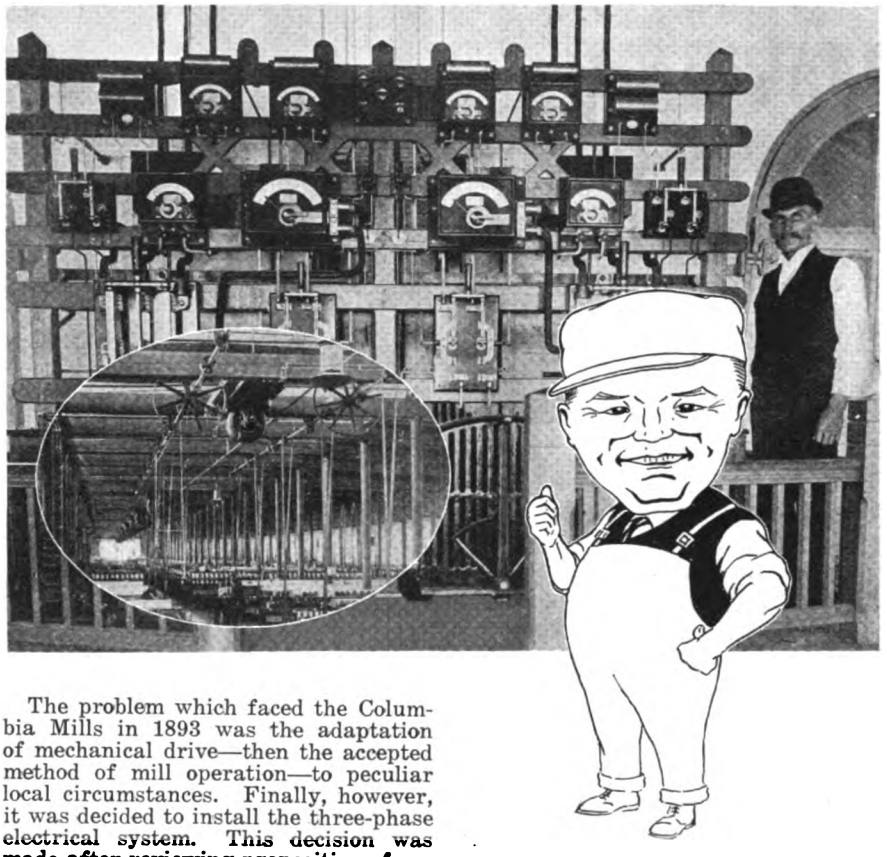
From an electrical standpoint, this industry is today well toward the top of the list from the standpoint of number of motors operated, largely because of the opportunity to use individual drive on textile machines.

And all of this has happened during the past 30 years. At the plant of the Columbia Mills at Columbia, S. C., the first application of an induction motor drive was made in a textile mill, and this was the first such mill in the world to install a complete generating plant for operating motors on the premises and to adopt the plan of subdividing the mill into independently-driven sections.

The photographs show one of the first induction motor drives in the plant of the Columbia Mills, and an old, wood-frame switchboard installed in the power station.

Another interesting point about this installation is that the original electrical equipment is still running and giving satisfactory service. Of the fourteen motors installed, only seven have been rewound and five of them are running on their original sleeve bearings.

In checking up with the Engineering Department of the General Electric Company on this motor installation, I have received the following comment:



The problem which faced the Columbia Mills in 1893 was the adaptation of mechanical drive—then the accepted method of mill operation—to peculiar local circumstances. Finally, however, it was decided to install the three-phase electrical system. This decision was made after reviewing propositions from three competitive manufacturers, two of whom suggested the use of direct-current motors of large size to drive the shafting which would ordinarily be used in a mechanically-driven mill. In April, 1894, two 500-kw., 108-r.p.m., 3-phase generators direct connected to two pairs of 48-in. horizontal water wheels were installed and fourteen 65-hp. induction motors were used for operating the mill.

At the time the installation was made there was no record of any motor having been used in a cotton mill. These motors were the first to be inverted and suspended from the ceiling, and it was the first instance where a motor shaft was extended at both ends.

The normal rating of the motors when installed was 65 hp. each. During their thirty-two years of operation the average load has been from 80 to 85 hp. Rewinding has been actually necessary on but five of the stators, two having recently been rewound as a precautionary measure. The only repairs needed by the motors were of a minor character. Some of the motors were run, in addition to their thirty-two years of day operation, for at least ten years on night operation, giving an equivalent of forty-two years of service since the original installation.

At the time the motors were installed they were the largest of that type in horsepower rating which the General Electric Company had made. The largest three-phase induction motors built before that time were 10-hp. machines, a single 5-hp. unit being the largest sold.

Credit for this piece of pioneering goes to C. K. Oliver who ordered the equipment in 1893, and Sidney B. Paine, who handled the work for the General Electric Company, with the late Charles P. Steinmetz in the background as a combined engineer and salesman. It is on the results of such pioneer work as this that mill and factory electrification today owes its rapid progress and no one would dare predict now just what it will be like in extent or nature thirty-two years from now.

Practical Pete

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A LOAD SURVEY of an industrial plant will often expose conditions which cause the power cost to be higher than necessary. Perhaps the diversity factor may be improved so as to cut down the maximum demand. Possibly the connected-load factor will indicate an over-investment in drive equipment. Again, power factor investigations may disclose ways to cut power costs. In this article Mr. Stafford tells how to determine and use these factors to interpret load conditions in your plant.

How to Go About

Making a Survey of the Power Load

In an Industrial Works Together With Methods of Analyzing the Data so as to Cut Power Costs

By H. E. STAFFORD
Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ontario

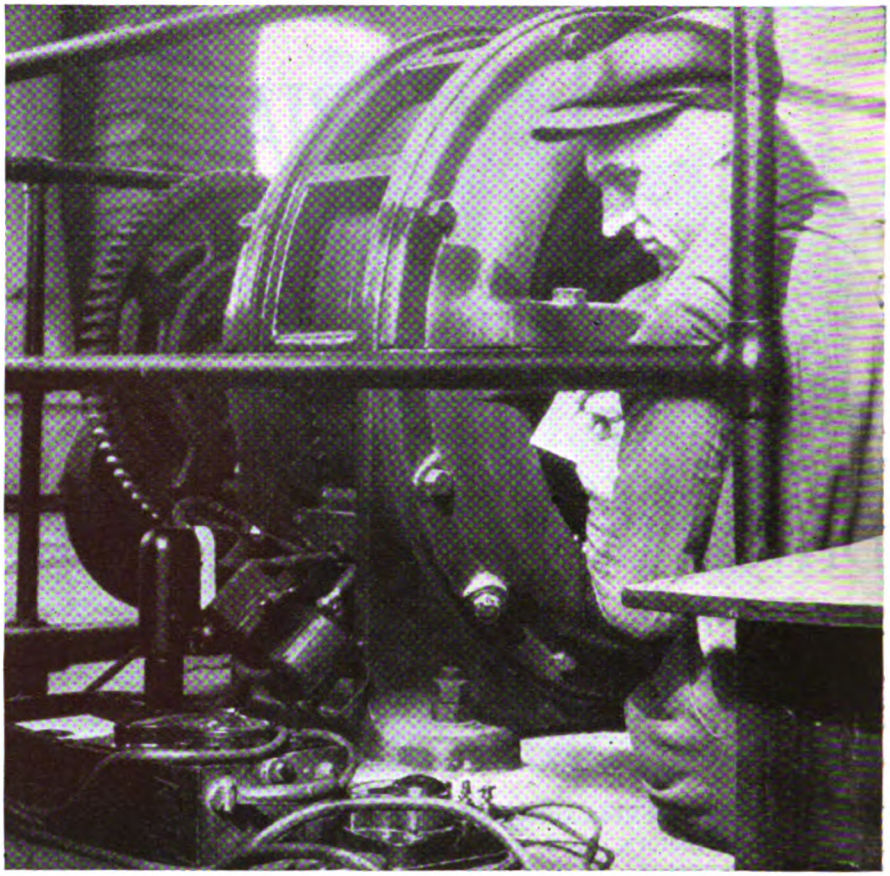


Fig. 1. A check is being made of the voltage and current supplied to this motor.
Less than rated voltage lessens the torque developed by the motor, which causes it to run at less than rated speed. Comparison of the ammeter reading with the ampere rating given on the nameplate of the motor will show whether or not the motor is overloaded and in danger of overheating. The ammeter reading does not give a true indication of the power developed by the motor unless used in connection with the efficiency and power factor curves of the motor.

THE primary object of making a load survey is to determine whether the power is being economically consumed. Making a survey involves measuring the loads on individual equipment and locating and determining any electrical or mechanical losses that may exist there. It is also necessary to summarize the individual loads so that they can be analyzed and comparisons drawn by means of the following factors: power factor, load factor, connected-load factor, demand factor, plant factor, and diversity factor. These factors are all expressed as percentages and it is through an interpretation of these factors and the losses found from the survey that conclusions may be reached as to whether the power consumed is being used economically.

Before taking up in detail the factors just mentioned, let us consider some of the mechanical and electrical losses that may be found in the average industrial plant.

The mechanical losses in power consumption are usually termed the friction load and will vary with each type of mechanical drive and with each individual unit. The least friction load is found where the drive is direct through a coupling, as with most centrifugal pump installations. Here, the friction load consists merely of the bearing and running plate friction and should not, when added to the magnetizing current or no-load current of the motor, exceed 20 per cent of the full-load current rating. For convenience, the friction load will, in this article, include the load due to the magnetizing current.

Gears of various forms constitute a friction load slightly in excess of the coupling drive, with an average of approximately 20.5 per cent of the full-load current rating of the motor. Gears should mesh properly; otherwise the friction load will increase considerably above normal.

Rope, chain and belt drives produce a greater friction load than those drives mentioned above, even under the most advantageous circumstances. The friction load with these types will reach as high as 30 per cent of the full-load current rating unless carefully checked. The average should not exceed 25 per cent even with lineshafting, if the use of power is to be considered economical. Where the connecting link is a chain it should have a certain amount of play and should never be tight, as a tight chain has no give or elasticity and imposes an excess of friction load, besides lessening the life of the bearings and chain.

With rope drives, the most economical method of saving power or reducing the friction load and preventing slippage, is by means of counterweight pulleys, the weight of which can be increased or decreased until a point is reached where both the slippage and friction load are minimum.

Where leather or composition belts are used, considerable losses may result unless belt tension is properly adjusted and the proper size of belts and pulleys is used.

Lineshafting is the cause of a heavy friction load in many cases; consequently, a great amount of care should be taken in its installation, particularly as regards alignment and the type of bearings used. Ball and roller bearings, while more expensive in first cost, will usually make up for the extra cost in re-

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duced friction load, lessened lubrication and lower maintenance costs.

Considerable power is lost in a great number of cases due to improper size of pulleys. The pulley furnished with the motor should not be changed without studying the application carefully, since the size furnished will in all cases be the most suitable for the type of motor. In 99 cases out of 100, haphazard changing of pulleys results in increased friction load, and is often disastrous to the motor.

The mechanical losses that have just been described can be readily checked by connecting a wattmeter, ammeter, and voltmeter in the individual motor circuits and noting the effect of any mechanical readjustments on the load taken by the motor under test.

Besides the mechanical losses that have just been discussed, there are some electrical losses that should be considered in making a load survey.

The electrical losses of a system using direct-current motors do not increase the cost of power to the same extent as when alternating-current motors are used, and apart from the losses due to field excitation, they may be ignored. The field excitation, however, is practically the same at all loads and does not vary greatly with the size of the motor. For instance, the field amperes of a 30-hp., and a 55-hp., direct-current motor are identical. Where motors are underloaded, there is a slight mechanical or friction load which can be reduced by using the proper size of motor. Apart from the losses mentioned above, the remaining losses may all be considered as mechanical losses.

Where alternating current is used, the case is somewhat different. Since alternating-current motors operate on the principle of induction, there is considerable loss due to the magnetizing current in the windings, even in a motor running without load. The writer has found cases where the no-load current of an induction motor was 25 per cent of the full-load rating, and cases where it amounts to 20 per cent are common. On a recent test of a 175-hp. induction motor, with a full-load rating of 176 amp., the losses averaged 37.5 amp. per phase, or 21.3 per cent of the full-load rating.

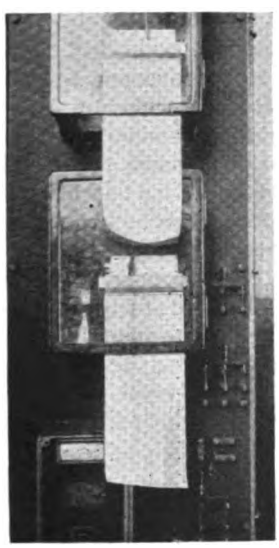
As this magnetizing current is present at all times when the motor is running, and in almost unvarying quantity, it becomes an important loss if, for instance, the motor is carrying only 50 to 75 per cent of its normal load most of the time. It should be a well-known fact among users of induction motors that an underloaded induction motor is an undesirable quantity. In the first place, the power taken by an induction motor consists of two components. One is an energy component, which is expressed as useful or available power, while the other, which is due to the magnetizing current required by the motor, is called the wattless or reactive component. This latter component is capable of no work and may, therefore, be considered a loss. The ratio of the two components determines the power factor of the load.

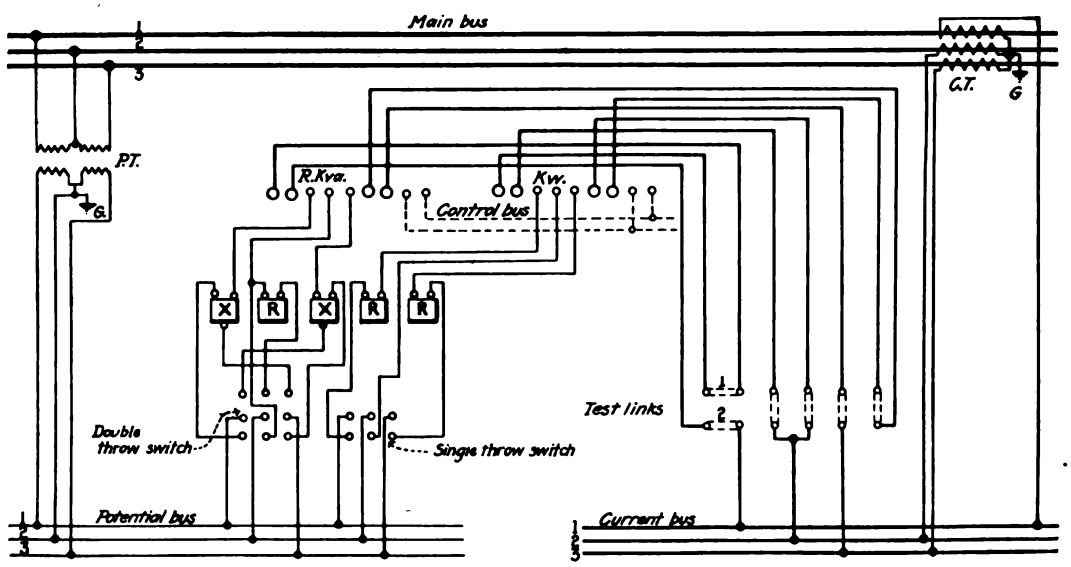
In a general sense, the power factor of a motor or a system of motors really expresses the ratio of the power consumed to the power paid for. For this reason power factor is usually considered of primary importance in a load survey.

Most power producing utilities penalize their customers when their power factor falls below a certain percentage, usually 90 per cent lagging. Assuming that a power consumer is using 6,000 hp. at a system power factor of 75 per cent lagging, the basis of charge is then made on the difference between the power factor maintained and that called for, or $6{,}000 \div 0.75 = 8{,}000$. Thus, it may be seen that with a 6,000-hp. load at 75 per cent power factor, 8,000 hp. of transformer capacity, transmission line capacity and electric generator capacity are being used by the power company to supply this power consumer's load. However, since the power company usually does not penalize for that load between 90 and 100 per cent power factor, the load for which the consumer is charged is $8{,}000 \times 0.90 = 7{,}200$ hp., that is, he is charged for 1,200 hp. more than is actually used. The excess of 1,200 hp. consists mainly of the magnetizing current of the load previously mentioned and for which the power company has to maintain equipment. This excess

Figs. 2 and 3. Scheme for using two wattmeters for measuring power and reactive kilovolt-amperes.

Fig. 2 shows two graphic wattmeters, the top one of which is connected so as to measure true power; the wattmeter at the bottom has its potential coils connected so that the current and potential of this meter are in quadrature, thereby causing it to measure reactive kilovolt-amperes. Fig. 3 shows the connection scheme used. The terminals marked Kw. are the current and potential terminals for the wattmeter measuring true power, while the terminals marked R. Kva. are for the wattmeter measuring reactive kilovolt-amperes. The test links and switches shown in both figures are for quickly changing the connections of the R. Kva. meter so as to measure true power instead of reactive kilovolt-amperes.





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horsepower is not true power in the sense that it is actual delivered power; it is reactive power and ties up part of the capacity of the equipment generating, distributing or transforming the power.

Low power factor may be remedied by increasing the load on the individual motor or by the installation of either synchronous motors, or static condensers. Individual induction motors should not be overloaded beyond 10 per cent of their rating, as considerable of the overload is made up of an increase in magnetizing current, and while the power factor will increase even after full load is reached, the life of the motor is shortened. The methods of measuring power factor will be discussed later in this article.

Second in importance to power factor in making a load survey is the load factor.

The load factor of a plant or system is the ratio of the average power consumed to the maximum demand on the system for a specified period of time. Load factors may be determined by the month or year, the yearly load factor usually being the one considered in a load survey. In an industrial plant manufacturing a given article, where the duty cycle of the various machines is uniform, the load factor should be fairly high; in some cases as high as 80 per cent. The average manufacturing plant should have a yearly load factor of from 50 to 65 per cent. Plants such as grain elevators, coal and ore docks and others where the duty cycle is seasonal have load factors as low as 15 per cent. The value of this factor in the economical use of power and reduction of losses, lies in the fact that once determined, steps may be taken whereby the duty cycles of some departments may be made to overlap, and the power curve kept in as nearly a straight line as possible.

Also, most power companies base their power charges on an energy charge for the power consumed and in addition, on a demand charge for the maximum demand made upon them for power during a certain interval of time. Ideal conditions are reached when the load factor is 100 per cent, for then the maximum demand equals the average demand or average power consumed and the power charges would be the lowest obtainable for that amount of power. As the load factor decreases from 100 per cent, the power charges will be increased on account of the increase in the demand charge.

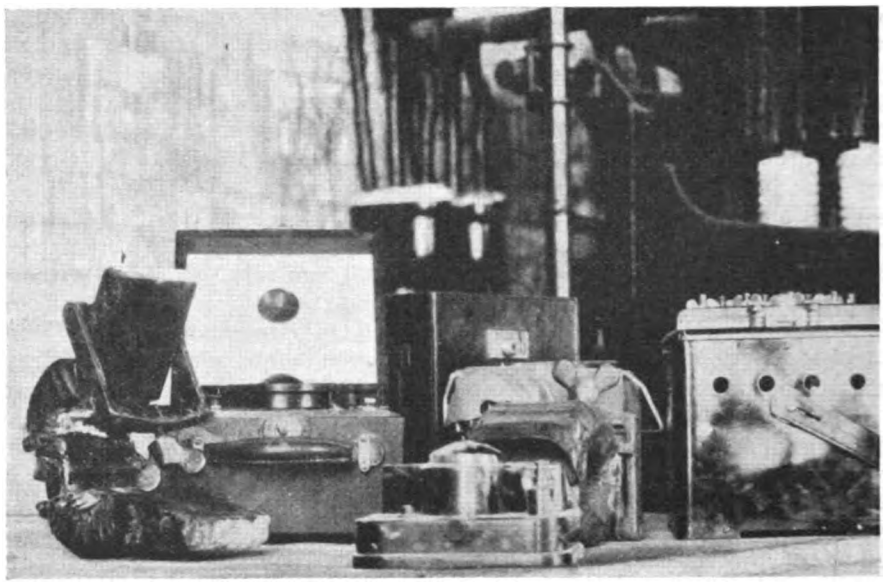


Fig. 4—Here are some of the portable testing instruments used in one industrial plant.

At the left is a split core current transformer having two ratios, one of 25 to 1 and the other 50 to 1. Immediately to the right is a voltmeter having a 300-volt and a 600-volt scale. In the center foreground is an ammeter having a 5-amp. scale for use with a current transformer, one of which is immediately behind it. Behind the current transformer is a megger for use in measuring insulation resistance and other resistance. At the extreme right is a solid core current transformer having 5 to 1, 10 to 1, and 20 to 1 ratios.

The average load, as used in calculating the load factor, is determined by dividing the total kilowatt-hours consumed during a certain period by the number of hours during that period. This gives the average kilowatt-hours per hour which is equivalent to the average kilowatts. The maximum demand is measured by a demand meter or may be obtained with the aid of a graphic meter.

Another factor dealing with the economical use of power is the connected-load factor. The connected-load factor of a plant or system is the ratio of the average power consumed to the connected load of the plant or system. The nearer these quantities are to each other, the more economical is the operation of the plant from the power standpoint. If the sum of the ratings of all of the motors in a plant is equal to 1,000 kw., and the average load drawn by these motors is 500 kw., the load factor is equal to 500÷1,000=50 per cent.

While the power charges are not usually based on the connected load, still the fact remains that there is an extra 500 kw. of motor capacity available, which is not used and which at one time represented a capital expenditure. It is practically impossible, in a plant having from 50 to 100 motors, to work all the motors to their full capacities every day of the year, but for economy the connected-load factor of the average plant should be almost as high as the load factor. The connected-load factor is also known as the capacity factor.

Three other factors that are of help in determining whether the power consumed and the equipment consuming it are economically used, are the demand factor, the plant factor, and the diversity factor.

The demand factor of a plant or system is the ratio of the maximum demand or highest peak for a predetermined interval to the total connected load of the plant or system. The demand factor of a small plant utilizing one or two motors that are overloaded will be high. The writer has found instances of load factors as high as 125 per cent. On the other hand, where there is a considerable number of motors, the demand factor may not be higher than 70 per cent. In the average industrial plant, a demand factor of from 85 to 95 per cent is considered good. The value of the demand factor in a load survey is to determine whether the generating and transforming equipment are out of proportion to the total connected load. If the yearly demand factor is 80 per cent of the total rating of the motors, the generating and transforming equipment need not be greater than 80 per cent of the total rating of the motors.

The plant factor of a plant or system is the ratio of the average power consumed to the rated capacity of

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the generators, transformers, etc., and is usually slightly lower than the load factor and sometimes equal to the connected-load factor. Its value in a load survey is a further check on demand and other factors.

The diversity factor of a plant or system is the ratio of the sum of the maximum demands of individual loads to the maximum demand of the entire group. Most industrial plants are split up into manufacturing departments, and when all of these various department loads occur at the same time, the diversity factor is unity or 100 per cent. Where the various department peak loads occur at the same time, it is often possible to change the operation so as to stagger the peaks and thus make a more even load and reduce the capacity needed in the generating and transforming equipment. Hence, it is seen that a diversity factor of 100 per cent represents the worst possible condition.

Methods and Instruments Used in Making a Load Survey

From the foregoing it can be seen that in making a load survey it is necessary to determine the connected load, average load, power factor, maximum demand and any abnormal mechanical or electrical losses that may exist. The connected load is, of course, the sum of the ratings of all motors or other energy-consuming apparatus connected to the system. The average load may be measured with a wattmeter, or a graphic wattmeter as shown in Fig. 2.

Power factor may be measured by means of a power factor meter, two wattmeters, or by a wattmeter, ammeter, and voltmeter. Thus, we see that in the last analysis we need instruments to measure watts, volts, and amperes. From the data taken by these measurements we can arrive at the factors and values mentioned previously.

There are several methods of making a load survey, each method depending on the instruments at hand

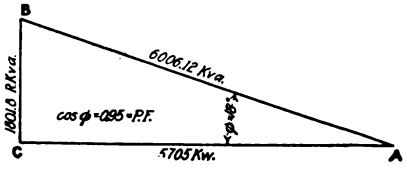


Fig. 5. Relations existing between kva., kw., reactive kva., and power factor.

AB represents the kva. and *AC* the kw. or power component of the load while *BC* is the reactive kva., or wattless component of the load. Power factor is represented by the cosine of the angle between *AC* and *AB*, which is equal to *AC* divided by *AB*.

and the quality of the test. For an elaborate test, two portable graphic wattmeters may be used, one of which has its potential coils connected so that the current and potential of that meter are in quadrature to each other. This method gives very accurate results. The connections for such a test are shown in Fig. 3. Also two switchboard graphic wattmeters connected in this manner are shown in Fig. 2. One wattmeter gives the total kilowatts consumed and shows also the peak at any instant. The remaining wattmeter registers the reactive component of the load. The power factor of the entire system, individual motor, or department group of motors, is then found through the use of the formulas:

$W_1 \div W_2 = \tan a$ and

Cos a=power factor,

In which W_2=reading of wattmeter giving the power component, and

W_1=reading of wattmeter giving reactive component; that is, its current and potential coils are connected in quadrature.

In this formula, a=angle of lag or lead between W_2 and W_1.

In other words, the reactive component reading divided by the energy reading equals the tangent of the angle of lag or lead between these two components. The cosine of this angle is the power factor of the load under test.

For instance, suppose the reading of the wattmeter W_2 equals 4,800 kw., while the reading of the wattmeter showing the reactive component, or the R. Kva. meter is 2,400 kva. The ratio, 2,400÷4,800=0.5, which is the tangent of the angle. The angle in this case is 26.6 deg., and the cosine of 26.6 deg. is 0.89, which makes the power factor equal to 89 per cent lagging.

Another method of conducting a survey is by means of a wattmeter, an ammeter, a voltmeter, and a power factor meter. The hook-up is as shown in *A* or *B* of Fig. 6. This will give practically the same results as the previous test and if the instruments are of the graphic type, a permanent record is obtained. It is not necessary to have a permanent record, however, and since ordinary measuring instruments are less expensive than graphic instruments they are more widely used. With this arrangement, the instantaneous readings of the meters are taken and the power factor is checked against the reading of the power factor meter from the readings of the other three instruments, by the use of the following formulas:

For single-phase circuits, Power factor=kw.÷kva., or kw.÷(volts× amp.×1,000). For two-phase circuits, Power factor=kw.÷(volts× amp.×1.41×1000).

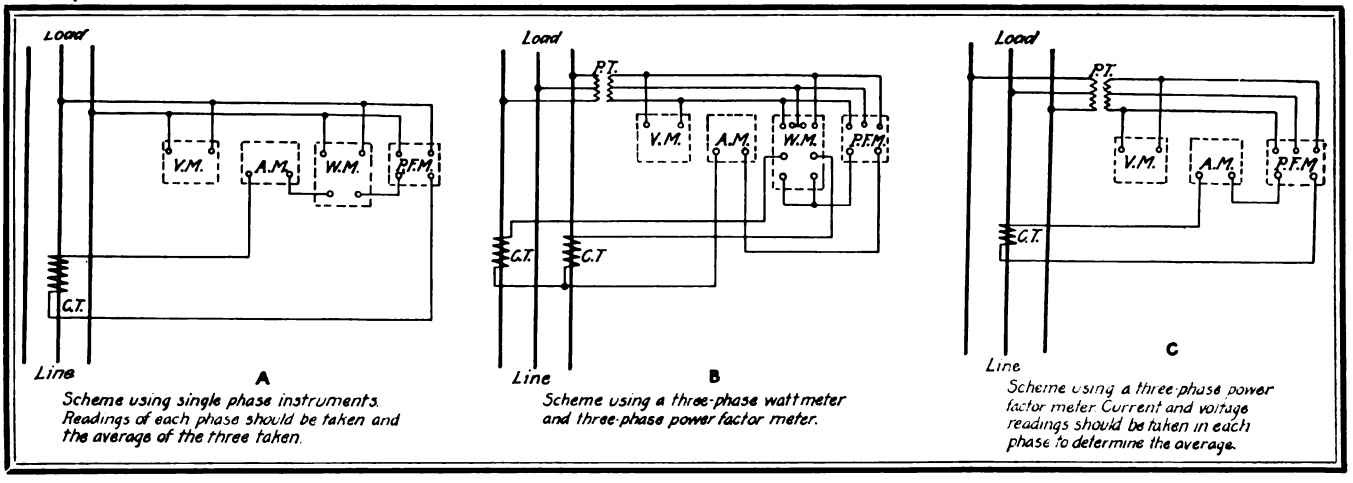


Fig. 6. Connection schemes for measuring volts, amperes, watts and power factor on three-phase circuits.

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For three-phase circuits, Power factor=kw.÷(volts × amp. × 1.73 × 1,000).

A power factor meter is not essential unless it is desired for checking the accuracy of the results obtained from the readings of the other instruments.

Another method involves the use of an ammeter, a voltmeter and a power factor meter, as shown in *C* of Fig. 6. Although this method does not check the kilowatt consumption, if the meters used are accurate the kilowatts can be found from the following formulas:

For single-phase circuits, Kw.= (volts×amp.×power factor)÷1,000.

For two-phase circuits, Kw.= (volts×amp.×power factor×2)÷1,000.

For three-phase circuits, Kw.= (volts×amp.×power factor×1.73)÷1,000.

Some of the meters used in making these tests are shown in Figs. 2 and 4.

Data Obtained From Load Survey of an Industrial Plant

To get a better understanding of the usefulness of a load survey let us consider the case of an industrial plant having a connected load of 7,500 hp., made up of miscellaneous induction and synchronous motors of various sizes and speeds. These motors are grouped under five departments, each department supplied from a separate panel or group of panels, each panel being equipped with a circuit breaker and an ammeter. A check of the various department loads shows ratings of 1,500, 2,000, 900, 2,500 and 600 hp., respectively. This gives a total of 7,500 hp. The average amperes, as shown by the panel ammeters, corresponding to the above loads in their respective order are 1,200, 1,500, 800, 2,200, and 500 amp. at 550 volts. The loads in kilovolt-amperes for the respective departments are then 1,143.12, 1,428.9, 762.08, 2,195.72, and 476.3 kva., or a total of 6,006.12 kva. A totalizing wattmeter shows the average load to be 5,705 kw., so that the average system power factor is 5,705÷6,006.12 =0.95 or 95 per cent. When shown by vectors, the actual power in kw., the apparent power in kva., and the reactive kilovolt-amperes appear as in Fig. 5.

In this plant the yearly power consumption as measured by the watt-hour meter is 31,000,000 kw.-hr. Inasmuch as there are 8,760 hr. in a year, 31,000,000 ÷ 8,760 = 3,538.8 average kw.-hr. per hour, or the average kilowatt load. The maximum demand for the year as shown by the power company's demand meter is 6,000 kw. or 8,040 hp.

Survey of Motor and Feeder Ampere Loads

DRIVE	Rating HP.	Average Load Amp.	Av. Load of Group Amp.
Lineshafting.....	800	800	800*
Lineshafting.....	800	750	750†
Lineshafting.....	250	265	265‡
Elevator Legs....	100	110	
Elevator Legs....	100	90	375
Elevator Legs....	100	95	
Elevator Legs....	100	80	
Belt Conveyors..	40	45	
Belt Conveyors..	40	50	
Belt Conveyors..	40	30	
Belt Conveyors..	40	45	
Belt Conveyors..	40	35	
Belt Conveyors..	40	35	300
Belt Conveyors..	15	10	
Belt Conveyors..	15	9	
Belt Conveyors..	15	11	
Belt Conveyors..	15	8	
Belt Conveyors..	15	12	
Belt Conveyors..	15	10	
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	70
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	
Cleaner.....	10	7	
Miscellaneous....	25	22	
Miscellaneous....	25	26	
Miscellaneous....	5	3	
Miscellaneous....	5	3.5	
Miscellaneous....	5	4	75
Miscellaneous....	10	12	
Miscellaneous....	10	12	
Miscellaneous....	7.5	6	
Miscellaneous....	7.5	7	
Miscellaneous....	20	15	
Totals.....	2,800	.....	2,635

*Friction load = 265 amp.
†Friction load = 185 amp.
‡Friction load = 80 amp.

The following factors show the condition of the load. The power factor of 95 per cent lagging is exceedingly high. The demand factor, which is equal to the maximum demand divided by the connected load, or 8,040÷7,500=107.2 per cent, is exceedingly high and shows that the motors are being utilized at more than their full rating at times. The average load is equal to 3,538 kw. or 3,538×1.34=4,740 hp. Therefore, the connected-load factor, which is the ratio of the average load to the connected load, is equal to 4,740÷7,500=63.2 per cent. The load factor of this plant is the ratio of the average load to the maximum demand and is equal to 3,538.8÷6,000 =58.8 per cent. These two factors, while not so high as they might be, are average and show that considerable time is lost. These factors could be improved by increasing the kilowatt-hour power consumption, which would also mean increased production.

Let us consider another industrial plant that has a connected load of 2,800 hp., the load having been built up by various stages with no record kept of the characteristics of the load. The motors are supplied from two 600-volt, 1,000-kva., three-phase alternators located in the plant and driven by steam engines. It is found that the generators heat up to such an extent with all the motors operating that it is deemed necessary to install an additional alternator.

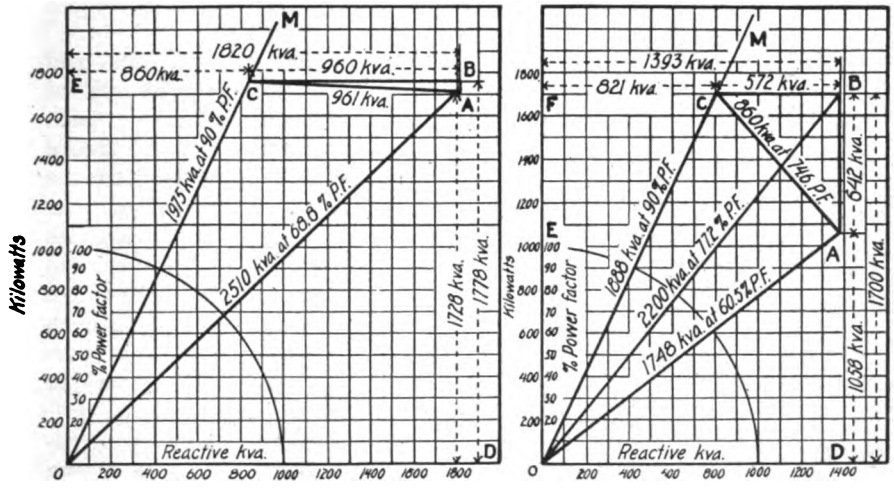
From a survey of the load conditions in the plant, the data shown in the accompanying table were developed. As can be seen from the table, power was distributed through seven feeder panels to motors which were served in the groups indicated in the table. On the three largest motors, the average load and friction load were measured by means of the ammeters on the feeder panels. In the case of the remaining motors the load on the individual motors was determined by connecting an ammeter at the motor as shown in Fig. 1, while the average load of the group was determined by the ammeters on the feeder panels.

In each case the load current of the individual motors was compared with the nameplate rating of the motor. Comparison of the friction load currents of the two 800-hp. motors disclosed that one was over 40 per cent larger than the other. Investigation showed that this was due to poor alignment of lineshafting and faulty bearings.

The average load of the miscellaneous group of motors is low in comparison with the capacity of the group of motors connected to this feeder panel, because all of them are not operating at the same time. Summing up the average current of each group of motors we arrive at a total of 2,635 amp. which represents the average current of the system. Since the motor voltage is 550 volts, the kilovolt-ampere load will be (2,635 × 550 × 1.73) ÷ 1,000 = 2,510 kva.

A wattmeter and a watt-hour meter were also connected in the supply to the feeders so as to measure the total kilowatts and total kilowatt-hours supplied to the system. The average of a large number of wattmeter readings was 1,728 kw. The maximum demand indicated by the wattmeter during a period of a week was 1,870 kw., while the watt-

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Figs. 7 and 8. Graphs that show how replacing a wound-rotor induction motor with a synchronous motor eliminated the need of more generator capacity.

In Fig. 7, *AO* represents the original load kva. at 70.7 per cent power factor. *CO* represents the result of using a synchronous condenser to raise the power factor to 90 per cent. After eliminating one of the wound-rotor motors, the load condition was as shown at *AO* of Fig. 8. This motor was replaced with a synchronous motor of capacity equal to *CA*. It pulled a power load of *AB* and supplied reactive kva. of leading power factor equal to *BC*, which resulted in the system load shown at *CO*.

hour meter showed a consumption of 225,965 kw.-hr. Assuming this to be an average week, the yearly energy consumption would be 52×225,965=11,750,180 kw-hr. These data were then put in the form of the accompanying report:

(1) Total annual power consumption —11,750,180 kw.-hr.
(2) Total number hours per day—8,760.
(3) Average kilowatt-hour consumption equals Item (1) divided by Item (2) equals 1,341 kw.-hr. per hr.
(4) Maximum demand—1,870 kw.
(5) Generator capacity—2,000 kw.
(6) Connected load—2,800 hp. or 2,089 kw.
(7) Average kilowatt load—1,728 kw.
(8) Average kilovolt-ampere load—2,510 kva.

Power factor equals Item (7) divided by Item (8) equals 68.8 per cent.

Load factor equals Item (3) divided by Item (4) equals 71.7 per cent.

Connected-load factor equals Item (3) divided by Item (6) equals 64.3 per cent.

Plant factor equals Item (3) divided by Item (5) equals 67 per cent.

Demand factor equals Item (4) divided by Item (6) equals 89.5 per cent.

The above report shows that with the exception of the power factor, which was exceedingly low, the various factors were a good average. It was recommended that the power factor of the system be raised to at least 90 per cent lagging so as to bring the kilovolt-ampere load within the rating of the generator. Three methods of doing this were presented.

The first method was to install static condensers; the second was to install a synchronous motor for power factor correction only; the third was to scrap one of the 800-hp. slip-ring induction motors and replace it with a synchronous motor.

The first two methods were turned down in favor of the third, which was thought to be the best. Details of the second and third methods are shown in Figs. 7 and 8.

Fig. 7 shows the original load conditions of 2,510 kva. at 68.8 per cent power factor, as represented by the line *AO*. The true power component of 1,728 kw. is represented by the distance *AD* and the reactive component of 1,820 kva. by the distance *BE*.

The smallest synchronous condenser that would raise the power factor from 68.8 to 90 per cent is shown by the line *AC*, which represents 961 kva. This condenser when operated at approximately zero leading power factor would supply a leading reactive component of 960 kva. *AB* represents the losses in the condenser which amount to 50 kw.

This would increase the true power to 1,778 kw. and would reduce the total kilovolt-amperes required by the system from 2,510 to 1,975 kva. thereby just getting within the 2,000-kva. rating of the generators. However, it would mean adding a 961- or 1,000-kva. condenser to the system.

Instead of using a synchronous condenser for power factor correction the synchronous machine might be run as an over-excited motor and substituted for one of the 800-hp. slip-ring induction motors. This would give us the benefit of the higher efficiency of the synchronous motor (93 per cent as compared with 89 per cent for the induction motor) as well as not increasing the number of motors that would have to be maintained. This plan was adopted and the resulting conditions are shown in Fig. 8.

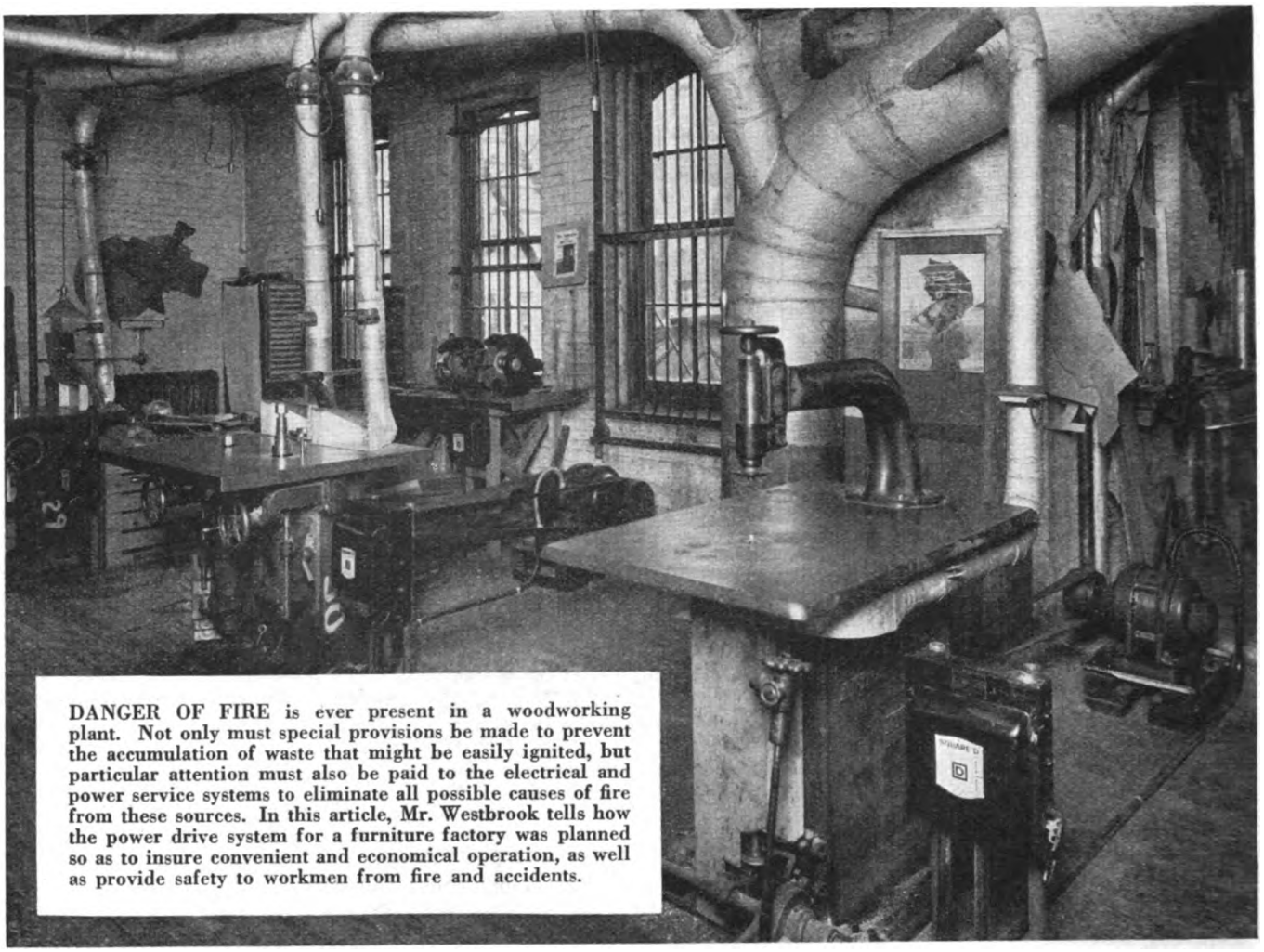
Since the 800-hp. slip-ring induction motors have an efficiency of 89 per cent, removing one of them reduced the load by (800×746)÷(0.89×1,000)=670 kw. Therefore the remaining load is 1,728 kw.—670 kw.=1,058 kw., or *AD* in Fig. 8. The kilovolt-ampere load of the slip-ring induction motor as determined by test was (800×550×1.732)÷1,000=762 kva. Hence in removing this motor the total kilovolt-ampere load would be reduced, 2,510—762=1,748 kva. as is represented by *AO* in Fig. 8. This load has a power factor of 60.5 per cent, for 1,058÷1,748=0.605, or 60.5 per cent.

The efficiency of a synchronous motor is somewhat higher than that of a slip-ring motor and for practical purposes may be figured as 93 per cent. Hence if a synchronous motor is substituted for the 800-hp., slip-ring motor, the kilowatt input to the synchronous motor will be (800×746)÷(0.93×1,000)=642 kw. This added to the 1,058 kw. load remaining gives a total of 1,700 kw. which is the total kilowatt or true power required if a synchronous motor is substituted for the slip-ring induction motor. In Fig. 8 *AD* represents the kilowatt load after removing the slip-ring motor; *AB* is the kilowatt input to the synchronous motor; and *BD* is the total kilowatt input or true power required by the system. The distance *AE* in Fig. 8 represents the reactive kilovolt-amperes taken by the 1,748-kva. load at 60.5 per cent power factor. This is equal to 1,393 kva. *BF* is drawn at right angles to *AB* from point *B* and also represents the reactive kilovolt-amperes shown at *AE*.

If the synchronous motor were operated at unity power factor, its capacity would only need be large enough to take care of the 642-kw. load represented by *AB*. In this case the total plant kilovolt-ampere load would be equal to *BO*. Scaling this and checking it against the power factor scale we find that *BO* equals 2,200 kva. at 77.2 per cent power factor. Since the generators are rated at 2,000 kva. it is necessary to over-excite the synchronous

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DANGER OF FIRE is ever present in a woodworking plant. Not only must special provisions be made to prevent the accumulation of waste that might be easily ignited, but particular attention must also be paid to the electrical and power service systems to eliminate all possible causes of fire from these sources. In this article, Mr. Westbrook tells how the power drive system for a furniture factory was planned so as to insure convenient and economical operation, as well as provide safety to workmen from fire and accidents.

Fig. 1—Convenient location of the control switch is an important factor in any motor installation.

In the center is a double variety machine or molder. The motor used for driving this machine has the shaft extended on both ends, which is fitted with two pulleys so as to drive each spindle with a separate belt. At the left and at the right are single variety machines. In the center background is a grinder. Note that in each installation the control switch is within convenient reach of the right hand of the operator as he stands at his work.

Some Practical Details of the

Power Service Layout For a Woodworking Plant

Including the Features of the Electrical Distribution System, Together with the Types of Motors, Control and Drives That Were Used

By FRANCIS A. WESTBROOK

Consulting Engineer, New Canaan, Conn.

IN A woodworking plant the great danger is the fire hazard. For this reason the use of the proper kind of motor and a carefully installed wiring system are of prime importance. The principles governing the method of meeting this condition in a woodworking plant are, of course, applicable in many other cases where a dangerous fire hazard exists. Special consideration was given this factor in planning the electrical distribution and power drive system for the new factory of Albano & Company, of New York City, manufacturers of high-grade furniture. The practice of placing all wires in conduit, even to the extent of using flexible conduit for motor leads, was followed throughout this plant. This feature and the use of enclosed-type, safety, motor disconnecting switches and squirrel-cage induction motors have reduced the fire risk from electrical causes to a minimum—one might almost say they eliminated it.

In a plant of this kind variable-speed motors are not required. Consequently, squirrel-cage motors may be used throughout and in this instance they are all 1,800 r.p.m. There are, in all 35 motors of various sizes as shown in the accompanying table. All are designed for 220-volt, three-phase, 60-cycle service.

The kind of building in which a power distribution system for such a group of motors is installed has more to do with the methods of installing conduits and panel boxes than is perhaps generally recognized. In this case, the new home of Albano & Company is a very substantial brick building but of an old

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type with wood floors, except the ground floor, which is concrete. There are five floors. The first (ground floor) and third are used for woodworking machinery, the second for storage and the fourth and fifth for upholstering and other hand work.

Under these conditions, the simplest method of installing conduit is to mount the panel box in a central location on the floor below that where the machines to be served are located. The conduits are then run on the ceiling of this lower floor from the panel box to a point directly under the control apparatus they are to supply with power, and pass up through the floor. Although it may at first thought appear that it would be inconvenient to have to run downstairs to replace fuses, this contingency should occur so rarely in a properly planned distribution system with conductors of adequate capacity, that it would not control the location of the panel boxes. Moreover, the fuses most likely to blow are those located at the motor starting switch and in each case these are located at the machine. The panel boxes and feeder lines for machines on the first (ground) and third floors are located in the basement and on the second floor respectively.

Obviously this method of installation is very simple, convenient and economical for these conditions, but it would be unsatisfactory if the floors were wet, especially if they were of wood, as in a laundry. In fact, ordinary wood floors would be out of the question in a laundry, but there are other processes which result in wet floors where moisture gets into the conduits and causes trouble in cases where the latter has been installed in this way.

Size and Number of Motors with Method of Drive Used in Woodworking Plant*

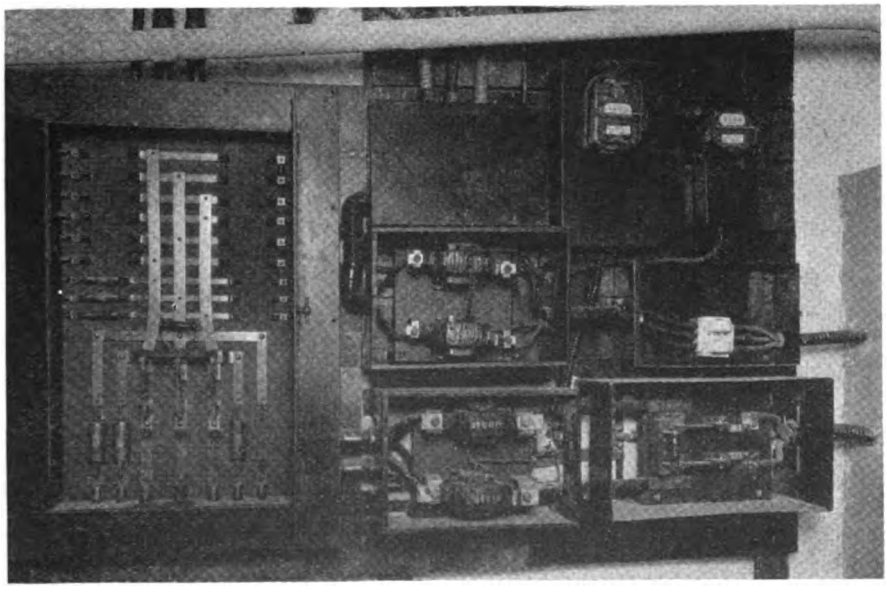
Name of Machine	Location, Floor	No. of Motors	Hp. of Motor	R.P.M.	Control	Drive
Blower for exhaust system	2	1	30	1,800	Compensator	Belt
Buss planer	1	1	10	1,800	Compensator	Direct
Jig saw	3	1	1.5	1,800	Starting Switch	Belt
Saw tables	1	6	3	1,800	Starting Switch	Belt
Horizontal borer	3	2	2.5	1,800	Starting Switch	Belt
Vertical borer	3	1	2.5	1,800	Starting Switch	Belt
Swing saws	3	3	3	1,800	Starting Switch	Direct
Band saws	1	2	3	1,800	Starting Switch	Belt
Double variety machine	3	1	7	1,800	Compensator	Belt
Single variety machine	3	1	5	1,800	Starting Switch	Belt
Dovetailer	3	1	3	1,800	Starting Switch	Belt
Carvers	3	3	3	1,800	Starting Switch	Belt
Single variety machine	3	1	3	1,800	Starting Switch	Belt
Fan for drying room	3	1	3	1,800	Starting Switch	Belt
Box shaper	3	1	3	1,800	Starting Switch	Belt
Jointers	1	3	3	1,800	Starting Switch.	Belt
Lathes	3	2	1.5	1,800	Starting Switch	Belt
Emery grinder	3	1	1.5	1,800	Starting Switch	Direct
Belt sander	3	2	2	1,800	Starting Switch	Belt
Rip saw	3	1	2	1,800	Starting Switch	Direct

*All of the motors listed here are squirrel-cage type.

Three-phase, 60-cycle, 220-volt power is delivered to the service entrance in the basement as shown in Fig. 2. As can be seen at the lower right of this illustration, the power goes through a disconnecting switch, and then through two 500-amp. current transformers (for metering) to the power panel shown at the left of Fig. 2. At the bottom of this panel is the 600-amp. service switch. Through the three 400-amp. fuses at the bottom of this panel, power is taken to two distribution panels, one in the basement and one on the second floor.

Fig. 2—Power service is brought into the basement of the building at this point.

The lower cable at the right furnishes the 220-volt, three-phase power supply, while the cable above it is the lighting supply. The circuits are carried to the left through the current transformers (for the two meters above), after which the power circuit goes to the main power panel shown at the left. The lighting current is fed directly from the current transformers to the lighting panels on the different floors. From the main power panel shown at the left, power is fed through the 100-amp. fuse gaps at the left center of the panel to the elevator motor. The 400-amp. fuse gaps at the bottom of the panel supply the two power distribution panels—one of which is located in the basement and the other on the second floor.



The power distribution panels are of the polarized type. The panel in the basement has a capacity of 12 circuits with eight 30-amp. and four 60-amp. gaps. Cables enter it from the main power panel, shown in Fig. 2, in two 2-in. conduits and there are three 1-in. and one ¾-in. conduits leaving it for distribution to the 12 machines on the floor above. The method of delivering the power to the individual motors on the first floor can be seen in Figs. 4 and 6.

The panel box on the third floor is fed through two 2-in. conduits coming from the panel box in the basement, the feeder passing through the latter box. Distribution to the 23 machines on the floor above is through five 1-in., three 1¼-in. and one ½-in. conduits as shown in Fig. 3.

It is evident that, in some instances, there is more than one circuit per conduit leaving the panel boxes. At certain points there are pull boxes from which separate conduits radiate to locations under their respective machines at which point the conduits pass up through the floor. In some cases it was conven-

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ient to locate these pull boxes above the floor, as shown in Fig. 5.

Fig. 3 shows the conduit and motor layout for the third floor. Some of the machines on this floor are shown in Figs. 1, 5 and 7.

As has been said before, all of the motors are squirrel-cage induction motors. This simplified the question of control, not only because the motors are small but also because there is no necessity of speed variation. Furthermore, the class of labor which operates the machinery is mechanically skilled and intelligent—a very different condition from that which exists in a laundry, for instance. Reference to the accompanying table will show that compensators are used for controlling all motors larger than 5 hp. A typical compensator installation is shown in Fig. 6. Power is delivered from the distribution panel in the basement to the safety switch mounted above the compensator. This safety switch is used for isolating the motor and compensator from the power supply when doing maintenance or repair work.

For motors smaller than 5 hp. a manually-operated motor starting switch is used. These switches start the motor across the line with the fuses cut out of the circuit. As the motor comes up to normal speed the switch is thrown to the running position, which cuts the fuses back into the circuit. Needless to say, these motor starting switches are of the safety type, being totally enclosed in sheet metal boxes. Typical installations of these starters are shown in Fig. 1. Wherever it was possible and convenient, the safety switches, compensators and motor starting switches were attached to the building columns, as shown in Fig. 4.

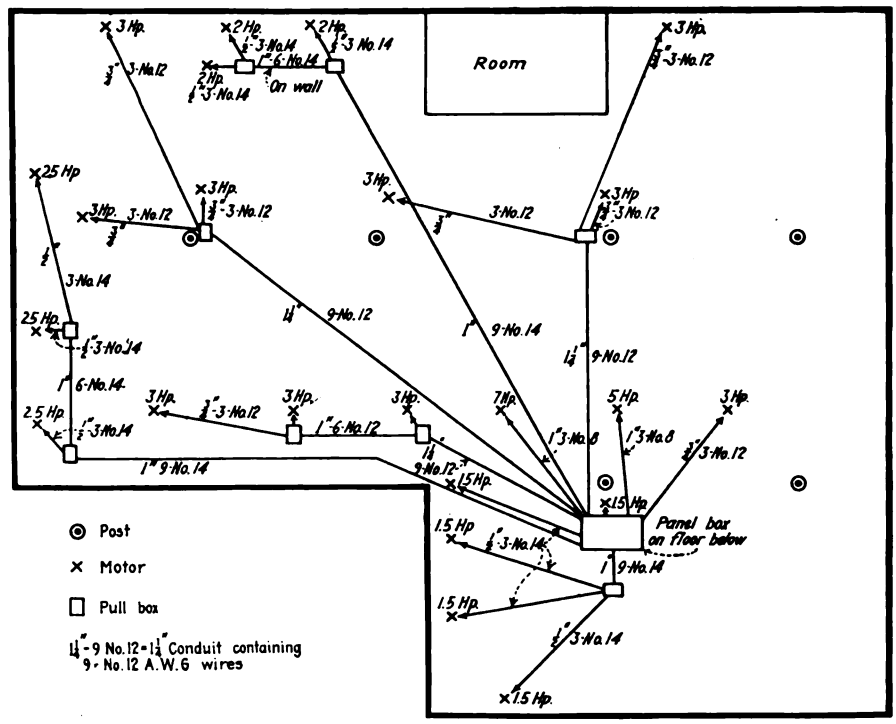


Fig. 3—Motor and conduit layout for the third floor.

A panel box was located on the second floor from which conduit was run on the ceiling of the second floor to points immediately under the locations of the third-floor motors. Conduit was then taken through the floor to the motor directly above it. This made a very simple and economical installation.

Convenience of control was the first consideration in each case, however, so that in many instances the control was mounted on pipe standards convenient to the machine operator's hand, as shown in Fig. 1.

The three swing saws, one rip saw, the emery grinder and the Buss planer are directly connected to the motors. In these instances the motors are mounted on the machines that they drive. All of the other machines are belt driven. The belted motors on the first floor are mounted directly on the concrete floor. Since the upper floors are of wood, the motors on the second and third floors are provided with drip pans under them so as to reduce the fire hazard from oil-soaked wooden floors. The method of installing the drip pans can be seen in Fig. 5. All of the motors were provided with conduit fittings which were connected by means of flexible conduit to the rigid conduit running from the control to

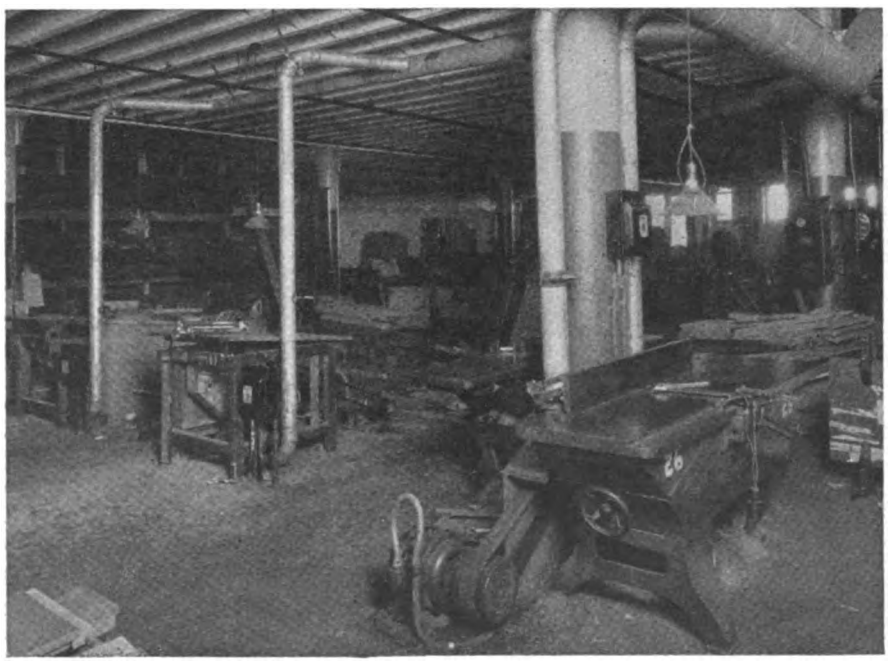


Fig. 4—Belt drives are used in the majority of cases in this shop.

In the right foreground is a jointer with its motor on the floor and control switch on the building column. Note how the motor leads enter the motor casing through flexible Greenfield conduit, so as to avoid all exposed terminals and to make a flexible connection between the rigid conduit and the motor so that it may be shifted on its slide rails in order to tighten the belt. In the left foreground are two saw tables. The control switches are mounted on stanchions. The conduits coming from the panel box in the basement may be seen coming up through the floor. The conduit from the switch to the motor is laid on top of the floor. To the right and at the rear, mounted on a column, will be seen the compensator and switch for the large exhaust fan located on the floor above. As that floor is used for storage purposes only, it saves much running back and forth to have this control apparatus on the ground floor where there are workmen all the time. There is an additional switch at the blower for the protection of men who maintain it.

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Fig. 5—Provision was made to take care of the wood waste by means of an exhauster system.

At the right are two belt sanders. As can be seen, one end of each is enclosed and connected to an exhaust pipe. Sawdust and other wood waste coming from these machines is sucked to a central depository. In this way much of the dust and dirt that would otherwise get into the motors is removed. On the left is a jigsaw with its control switch mounted on stanchions under the saw table. In the center background is a two-spindle horizontal drill with its control switch and motor. Notice how the motor belt on this drive, as well as those on the two belt sanders, is enclosed. At the extreme right between the floor and control switch of one of the belt sanders is one of the pull boxes shown in Fig. 3. Notice the drip pans placed under the belt sander motors to keep oil off the floor.

a point near the motor, as shown in Figs. 4 and 5. This method of installation not only avoided all exposed terminals and wires but also provided a flexible connection between the motors and rigid conduit so that the motor can easily be moved on its slide rails.

All belts and every other moving part, in so far as possible, are completely enclosed, thereby reducing the liability of accidents. These enclosures are boxes which may be readily disassembled for repair and maintenance work. As the foreman said, almost all of the old woodworkers have missing fingers or parts of fingers, but all of the young men are without these disfigurements, because of the great and effective precautions which are taken against accidents in modern plants. In fact, no accidents of any consequence have occurred since these enclosing guards were installed.

The exhaust system for carrying off sawdust and accumulations of dirt is very comprehensive, and is an important factor in reducing fire, health and accident hazards. The machines are equipped with hoods or other suction devices, as shown in Figs. 1 and 5. Also there are openings in a large suction pipe on each floor into which sweepings may be pushed without the necessity of carrying them away. One of these may be seen in Fig. 7. This is also of decided benefit from the standpoint of motor maintenance, as it reduces the amount of foreign material that might get into the motors.

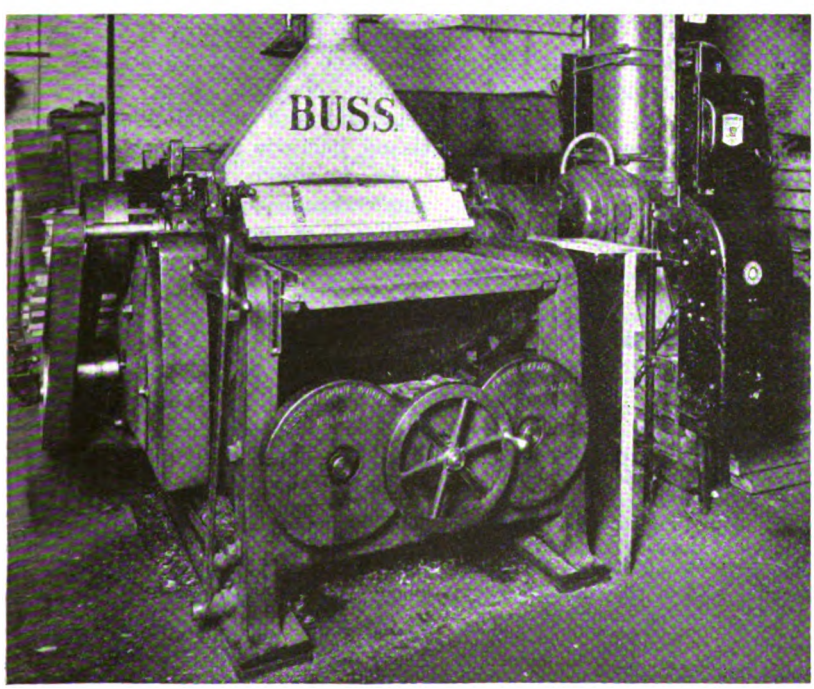
EDITOR'S NOTE: Special acknowledgment is made to MacNutt, Watts and Tankard, Electrical Engineers and Contractors, New York, N. Y., for the illustrations used in this article.

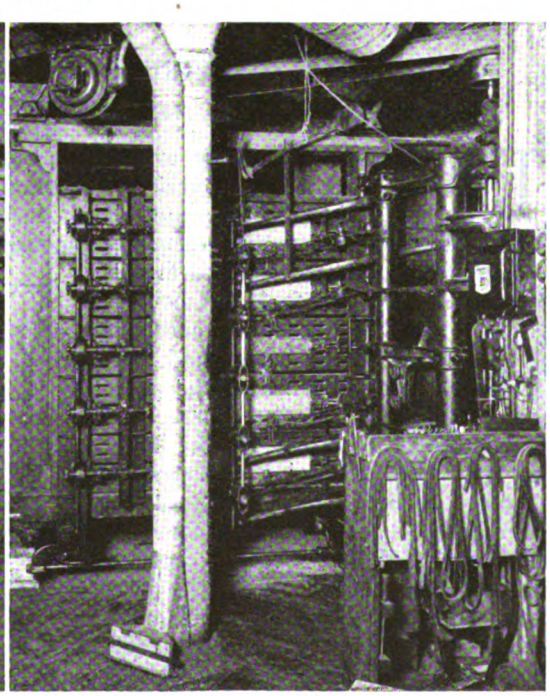
Fig. 6—Motor and control arrangement for Buss planer drive.

The belt on the left operates the feed mechanism; the motor is coupled directly to the machine. Normally, all belts and other moving parts are completely boxed in. This protection was temporarily removed while the pictures were being taken. The compensator, with push button stop, and enclosed-type disconnecting switch are shown to the right of the machine, in a convenient location for the operator.

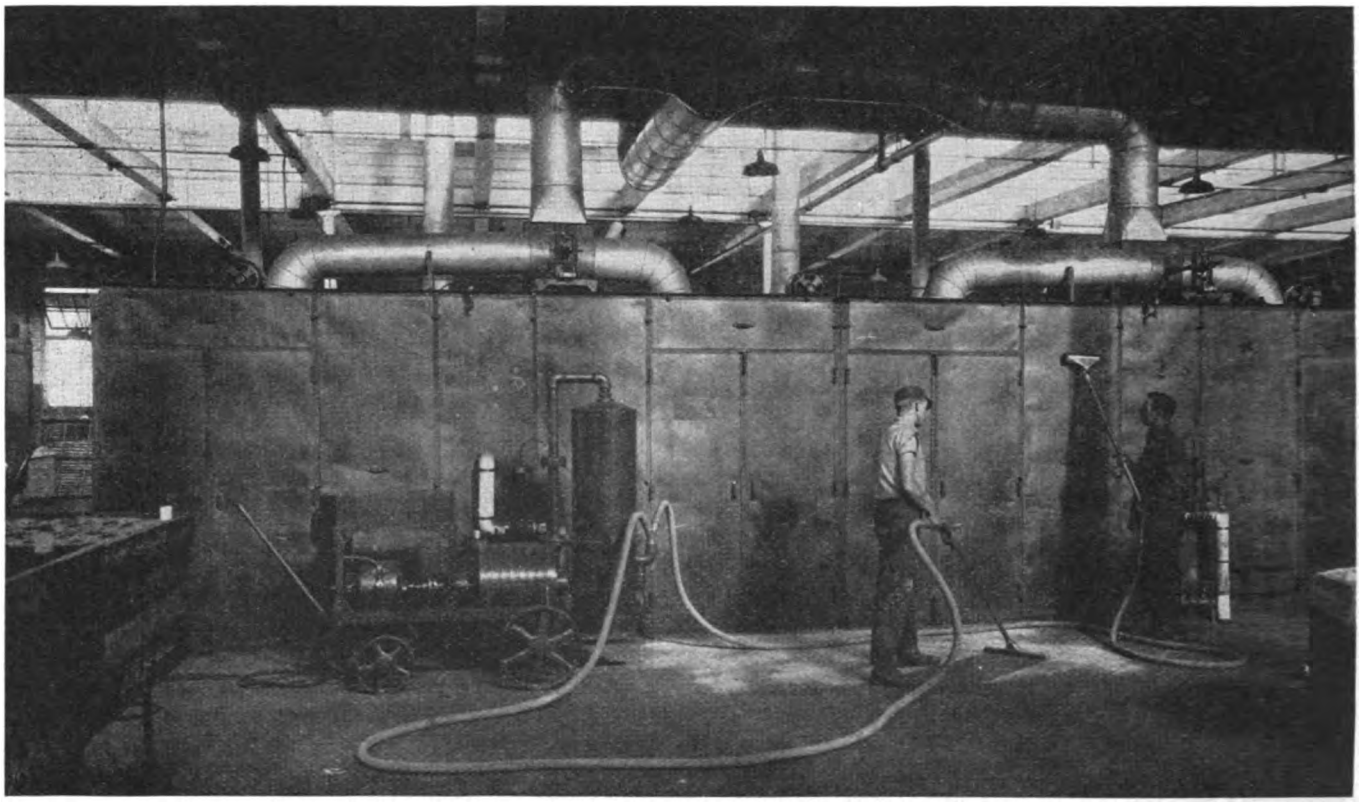
Fig. 7—Floor space requirements caused the motor driving this machine to be mounted on the ceiling.

This machine has a vertical drive shaft and as it covers considerable floor space which must be free for the operator to walk around in, the best place for the motor is on the ceiling where it, with its belt, is out of the way. The vertical shaft in the foreground at the right is driven by a twisted belt from the motor at the left. From this vertical shaft smaller belts go directly to each carving tool on the machine.





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Here industrial sweeping units are used to clean up the floor and the side walls. Solid material is separated in the cylindrical tank and does not go through the multi-stage exhauster driven by the motor.

Some Things It Pays To Know About

Removing Dust Produced in Industrial Plants

Including Equipment and Methods Used, With a Discussion of the Effects of Dust on Men and Machines and Its Relation to Fire Hazards

By CHARLES L. HUBBARD

Mechanical Engineer, Boston, Mass.

DUST exists practically everywhere and is produced to some extent in practically all industrial processes. Its removal is accomplished by methods and means similar to those described in connection with the article, "Removing Obnoxious Fumes, Gases and Vapors," which appeared in the June issue of INDUSTRIAL ENGINEER.

The fact that dust, even the heavier particles, will remain suspended for a time in the air is employed in removing it on the same principles as are used in removing gases, fumes and vapors. With the heavier dust, however, the problem of keeping it suspended is more difficult. Also it is generally desirable to remove the dust from the air before discharging into the atmosphere.

Dust is produced in an almost endless variety of ways and is often spoken of as man's worst enemy. It causes sickness and death, is responsible for fires and explosions, injures machinery and manufactured products, damages both interior and exterior surfaces and, in the aggregate, causes the loss of millions of dollars annually.

DUST REMOVAL problems in industrial plants are, like those connected with the removal of gases, fumes and vapors, solved by carrying the objectionable material along on a current of air. Some of the hazards, as well as the inconveniences, of atmospheric and industrial dust are taken up here, together with the equipment for handling it. Methods of removing the dust from the air current before discharging it into the atmosphere will be discussed in an article in a later issue.

There are many different kinds of dust, coming from the mineral, vegetable and animal kingdoms. That contained in the outside air, which is usually called atmospheric dust, is made up of a mixture of various organic and inorganic substances, such as coal, cinders, ashes, sand, loam, vegetable and animal fibers, animal tissue, bacteria and so on.

As a rough approximation, we may assume that one hundred-millionth of the volume of the air in the vicinity of the average power house consists of dust and other foreign particles. While this proportion of dust may seem negligible, and is, in fact, not so great as is often found, it means that the ventilating air passed through a large generator in 24 hr. will contain nearly 1 cu. ft. of solid matter. Some of this, if left in the air, would naturally be deposited upon the winding and later cause trouble.

Another interesting example of the amount of dust in the air is in connection with the air brought in

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for the ventilation of a large city school building where the outside conditions were such as to indicate an average atmospheric purity much above that which would ordinarily be found around industrial plants. Tests by means of an air filter showed that 50 lb. of dry dust were brought in with the air during each 6-hr. session of the school day. If this 50 lb. or more of dust is taken into the schoolroom or plant daily much of it is deposited on floors, walls, ceilings and on the top of equipment or projecting ledges. Some of the dust, of course, is carried out again as the air leaves the room or plant; that which remains must be cleaned up or removed periodically. The expense of this cleaning is of considerable importance.

That portion of the dust which settles on lighting units and any white walls or ceilings materially reduces the illumination of the plant. To overcome this requires periodic cleaning of lighting units and reflectors and repainting of surfaces. In addition to the dust ordinarily found in the atmosphere and which may be brought into the plant through an unprotected ventilating system, many industrial processes create dust. It is produced in an endless variety of ways, as in grinding and polishing, stone cutting, sandblasting operations, shoe manufacturing, woodworking, cleaning castings in foundries, the operation of pickers in textile mills and in many other operations or processes. Dust is also produced in great quantities in the manufacture of flour, sugar, starch, cement and in the crushing or handling of coal and other products. The lint of textile mills is also a form of dust which must be contended with.

Some of the Effects of Dust in Industry

While many kinds of dust found in the air are practically harmless in themselves, they serve as a means of transmission for various germs. Therefore, the first, and most important, step in the elimination of disease germs from an industrial establishment is that of clearing the air supply of all foreign substances.

The effect of dust upon health depends largely upon local conditions, such as its composition, concentration and the period of exposure. While a moderate amount of dust such as is commonly found in woodworking shops, shoe factories, foundries, and so on, is simply irritating to the respiratory passages, it often tends to bring on inflamed and infected conditions of the nasal passages which make a person especially liable to colds and other acute diseases of this class.

Metallic and mineral dust, which comes from the grinding and polishing of metals, stone cutting, sandblasting, and so on, is more harmful, as continued breathing of air loaded with these substances causes the heavy particles to accumulate in the lungs; "stone-cutters consumption" is a well-known malady among persons engaged in this occupation. Breathing the dust of poisonous substances like lead, is more rapid in its effects and is similar to the inhalation of a poisonous gas.

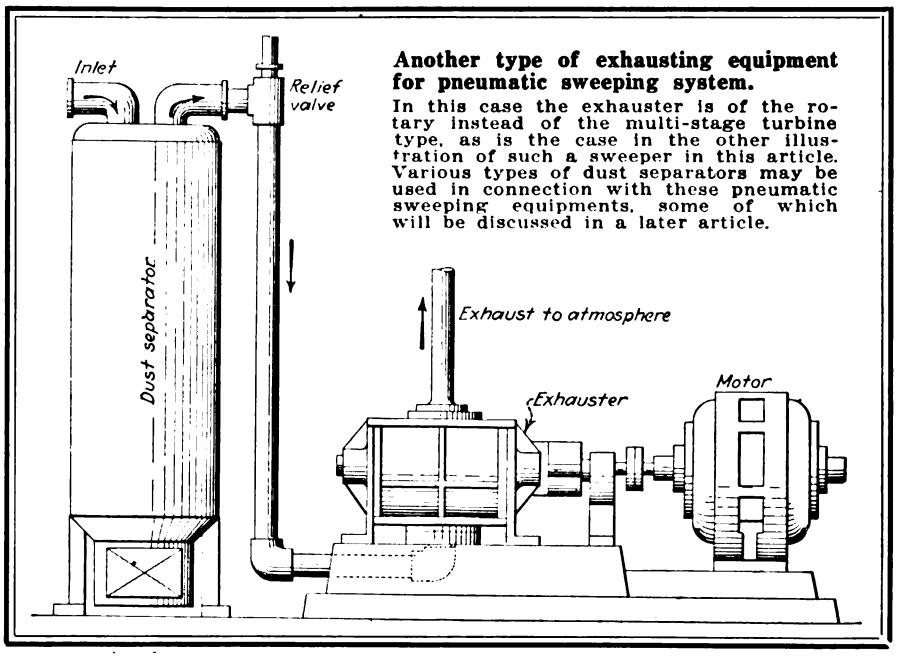
Some dusts are both inflammable and explosive. The fire hazard is increased in textile mills by the accumulation of lint around shafting and bearings. Fires have been traced to hot bearings which ignited the lint or dust around them. Also, if the shaft or bearing is overhead, oil-soaked lint may fall on the work in process and at least seriously depreciate its value if not make it entirely worthless. One of the big problems of textile mills is to remove this lint from the walls and ceilings of the rooms. It is also necessary to clean the lint off the machines themselves at frequent intervals to keep them in running order. Much the same condition occurs in woodworking and other shops where a bulky dust takes the place of lint.

In direct line with this is the danger of explosion where the nature of the process carried on is such as to fill the air with a fine carbonaceous dust, as in connection with the manufacture of wood products, charcoal, celluloid and so on. An example of the great danger which may be brought about in this way is the explosion which occurred in the Chicago and Northwestern grain elevator in Chicago in 1921, where the damage to property and loss of grain was estimated at $3,750,000.

Dust explosions in coal mines are also common. A similar hazard exists in connection with the pulverizing and handling of powdered coal in power plants, cement mills and other industries. The pulverizing of aluminum and hard rubber also create explosive hazards. Starch and flour mills have likewise been destroyed by explosions. About a year and a half ago, 42 men lost their lives in an explosion in a starch factory, which was attributed to a hot bearing in a screw conveyor.

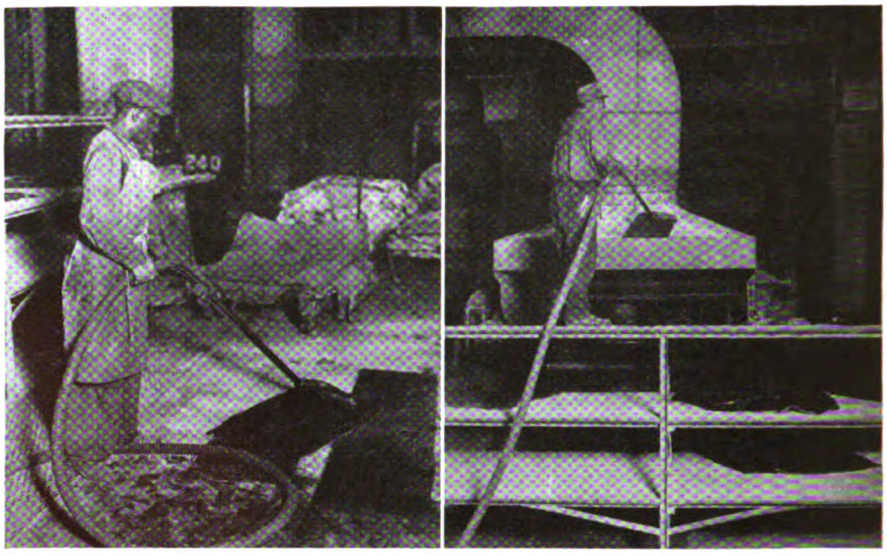
In most industries, however, the explosion hazard is negligible, although some of them, such as woodworking and others have a fire hazard. The more common dust removal problem is in connection with preventing dust from interfering with the machines, in keeping the plant clean and in providing clean air for a process or for the comfort, convenience and health of the workers.

Injury to machinery is produced principally by dust of a gritty nature which enters the bearings. This condition may be brought about by dust produced by the process or



Another type of exhausting equipment for pneumatic sweeping system.
In this case the exhauster is of the rotary instead of the multi-stage turbine type, as is the case in the other illustration of such a sweeper in this article. Various types of dust separators may be used in connection with these pneumatic sweeping equipments, some of which will be discussed in a later article.

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Two examples of a sweeping operation in a rubber plant.

These sections of vacuum units are connected to filters and an exhaust sweeping unit similar to that below. Some industrial processes produce a fine dust. If this were swept up by a broom the dust would simply be raised and much of it settle again. By the method shown here, it can be easily removed not only from the floor but from hoods, walls and other places. Vacuum cleaning is practically the only method of sweeping which will not raise a dust. In some industries and plants the sweepings which are gathered up in this way can be worked over again when removed by the filters.

from the use of unfiltered outside air as in the ventilation of generators and transformers. An important matter sometimes overlooked is that of filtering the air supplied to compressors and internal combustion engines, when it contains gritty particles which will score the cylinders.

Damage to goods in process of manufacture may occur in various ways, either from dust produced in the building itself or from that brought in from outside. This is illustrated in plants making fine silk or paper goods, where dust and dirty lint must be kept away from the manufactured product in its different stages. Other cases where dust must be removed from the entering air are in the manufacture and drying of food products, photographic films, prepared papers, chemicals, and so on. As previously stated, bacteria are commonly carried upon particles of dust. These organisms thrive upon gelatin, glue and certain food products, such as butter, milk and cheese, so that dust not only has a direct effect upon the quality when coming in contact with these substances, but may infect them as well.

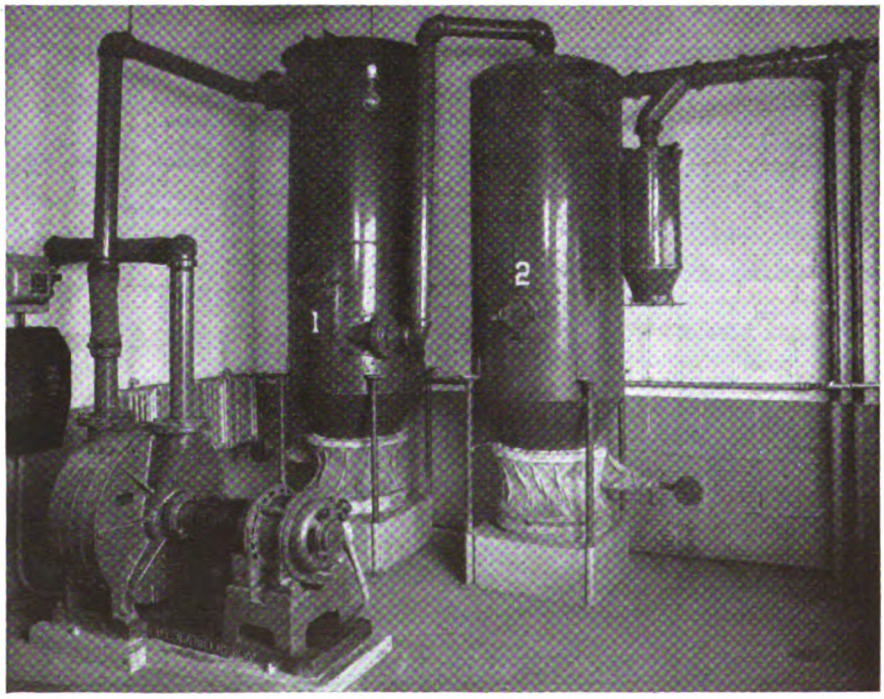
Methods of Collecting and Removing Dust

The operations of collecting, removing and disposing of both atmospheric and process-created dust are so closely related that they will be discussed together here. The problem of the disposal of dust after it has been collected must be carefully considered, as in many localities the free discharge of dust-laden air, outbound, will prove a nuisance to neighboring buildings and other property and often is not permitted.

The dust from cement kilns, flour mills, grinding and polishing machinery, sandblasting operations and so on, are illustrations of this. In certain manufacturing plants, it is not only desirable to collect and remove the dust for reasons already mentioned, but also for the purpose of reclaiming various waste substances which it contains. This is notably the case in gold- and silver-working establishments, where all sweepings and refuse from polishing machines must be carefully collected and treated. In other cases the precipitation of dust from heavy fumes or smoke is practiced at a profit. Most types of dust, however, have no value.

The removal of dust may be classed under four general heads, as follows (*a*) Removal as it is produced at the source. (*b*) Removal after mixing with the air of the room. (*c*) Removal after it has settled upon the walls, floor and other objects. (*d*) Removal from outside air supplied to the building and from that exhausted from it.

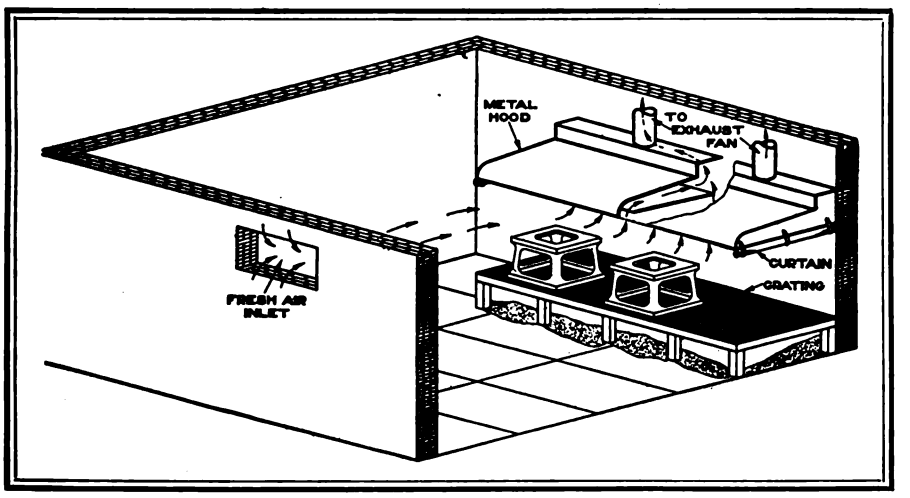
The methods and equipment for removing dust as it is produced at the source or after it becomes diffused in the room are quite similar to those used for removing fumes, gases and vapors as described in the previous article. The main difference is that because dusts are heavier they require a higher velocity of air



This heavy-duty stationary sweeping system unit was installed in the Cleveland, Ohio, plant of the Willard Storage Battery Co.

The dust and dirt are dumped automatically from the separating tanks Nos. 1 and 2 through chutes to bins located on the floor below. This apparatus is installed on the roof of the building in a special house built for this purpose. For this reason all of the dust and dirt must be drawn upward through vertical pipes such as are shown at the right, which go down to the floors where the sweeping is to be done. Men with hose lines and special sweeping units do the sweeping. Before the dirt passes through the multi-stage turbine exhauster it passes through the two separating tanks or filters.

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One type of ventilating arrangement for a sandblasting room.

Here the work to be sandblasted is placed on the grating. A suction through the metal hood above the work draws the dust away from the operator. The hood is open around the edge only to give a higher velocity of the entering air and therefore a greater suction. This method is also used in withdrawing gases and fumes. In some cases a suction is placed under the grating in the bench top also. Fresh air enters from the opposite side of the room.

to keep the particles suspended in the air and carry them away. Also, as previously mentioned, it is seldom possible to exhaust dusts into the open. This requires the addition of extra equipment to separate the dust from the air before it is exhausted, which, in turn, increases the head or pressure against which the exhaust fan works and so requires more power to operate than a similar system exhausting the same quantity of air containing fumes or gases directly into the atmosphere.

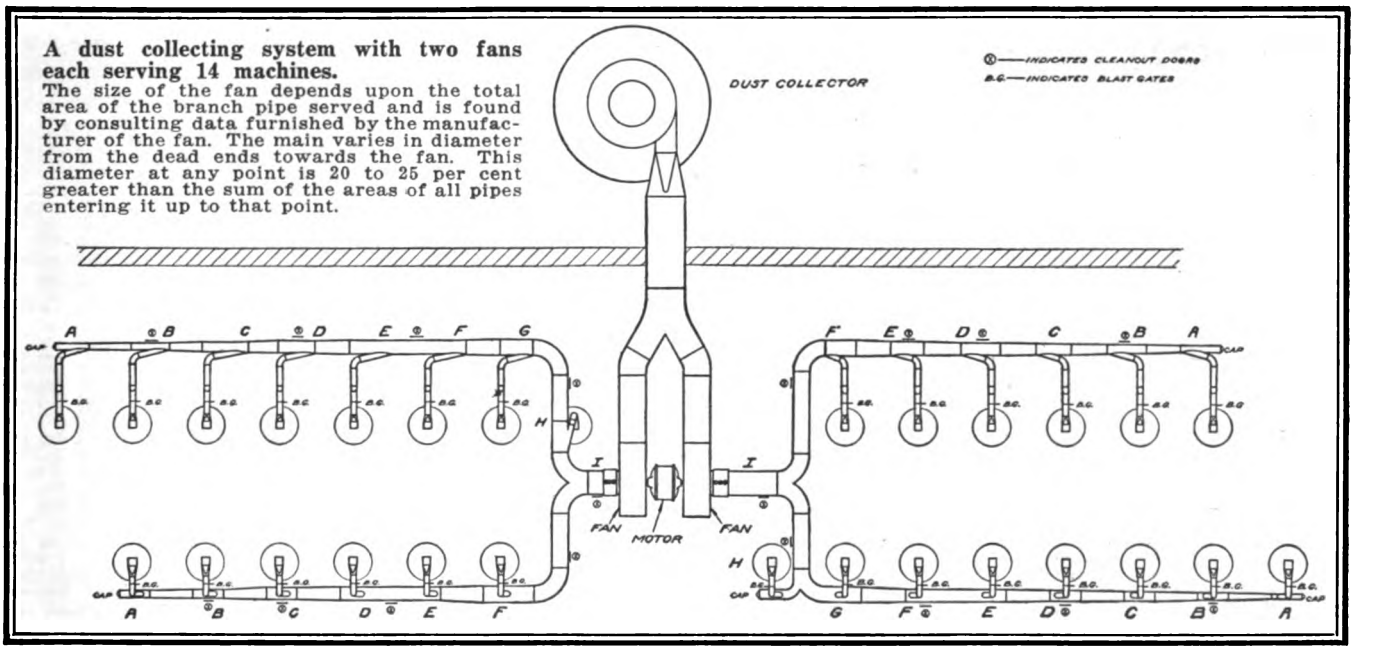
In the case of grinding and buffing, the wheels are surrounded with a hood, which is connected with the exhaust line and has just enough of the circumference of the casing cut away to reach the wheel easily for the work to be done. Other machines of various kinds are provided with similar hoods for carrying away the dust and fine refuse produced while in operation. The suction required will depend upon the nature of the dust, as to fineness, weight, and so on, and commonly runs from 2 to 5 in. of water column. Some states have factory inspection regulations which specify the suction to be maintained when exhausting different substances. The shape of the hood in all cases depends upon the machine and the requirements of operation. Tables I and II on page 355 give dimensions of exhaust pipes leading off from various machines.

It is desirable to keep the pipe as straight as possible, as bends or elbows increase the amount of power required to pull the air through them and still maintain the required suction and velocity. An elbow should have a center-line radius of 1½ to 2 times the diameter of the pipe. The resistance of this, however, is equal to a length of pipe ten times the diameter. Losses in pipes depend upon the size, length, velocity, and other factors. Most companies providing this type of equipment will supply tables for determining the requirements of a particular installation or will give advice and consultation on the problems involved.

Another factor to be remembered is that the volume of air delivered by a fan varies directly as the speed, while the air pressure created changes in proportion to the square of the number of revolutions and the power required to drive the fan varies as the cube of the speed. In other words, doubling the speed of the fan doubles the volume delivered (which is the measure of the capacity), increases the air pressure created to four times (the square) that previously existing, and increases the power required to eight times (the cube) what it was at the original speed. These are factors which are often overlooked in an installation, particularly when the question arises of increasing its capacity or adding additional connections to machines. These points should be kept in mind when planning for an installation, because a unit to be operated at full-load capacity saves on the original cost but has a high cost of operation. On the other hand, an oversize fan costs more in the first place but has a

A dust collecting system with two fans each serving 14 machines.

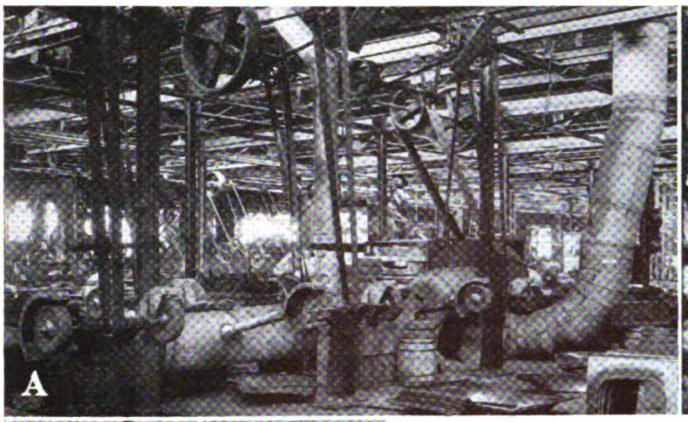
The size of the fan depends upon the total area of the branch pipe served and is found by consulting data furnished by the manufacturer of the fan. The main varies in diameter from the dead ends towards the fan. This diameter at any point is 20 to 25 per cent greater than the sum of the areas of all pipes entering it up to that point.

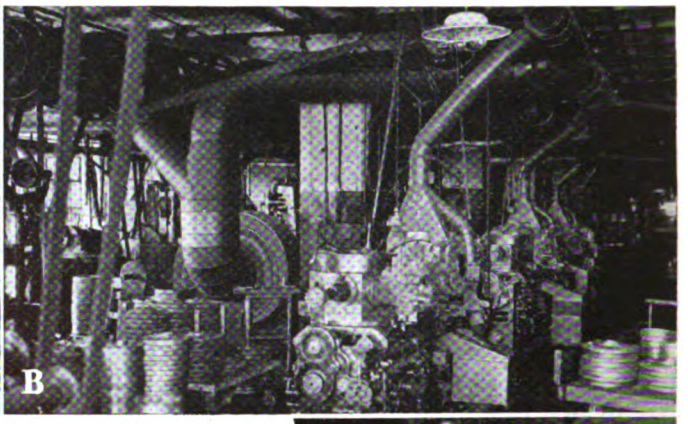


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How Dust Is Removed in Industrial Plants

Equipment and Methods That Have Wide Application











A—Here the exhaust main is placed between the rows of machines with small lead-off pipes from each machine. In some cases the exhaust main runs along on the ceiling of the floor below to save floor space.

B—Hoods, fitting closely around the machines, remove the cast-iron dust in the flywheel department of an automobile factory.

C—A propeller fan in the wall is used to remove the dust which arises when cleaning mattresses in a bedding factory.

D—All suction pipes, particularly connections from individual machines, should be provided with cut-off blast gates, similar to that shown in the outlet of a blower.

E—Here a propeller fan in a special hood is used to remove the fine dust caused when resurfacing paint grinding stones.

F and G—This portable electric tool for cleaning electrical and other machinery may be used as a blower F or as a vacuum cleaner G.

H—Another type of portable suction sweeping equipment used in cleaning telephone equipment. This is driven by a motor which gets its power from a lamp socket.

I—This vacuum sweeper is connected to heavy-duty equipment through pipes and hose. It is used here to gather up coal and dust from the floor in a power plant.

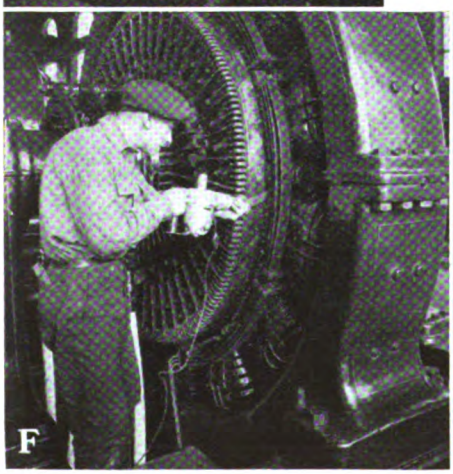
J—Propeller fans inserted in the windows are used here for general ventilation in a sandblasting room.

K—Hoods, such as one shown raised on the first machine, are placed over each machine to catch any lint which may be loosened. A blast gate in the pipe just above the hood enables each machine to be cut off when idle and so save on power used.













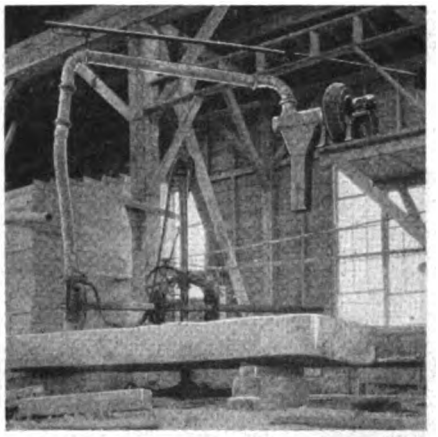
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lower operating cost. Also, additional units may be added without causing a prohibitive overload.

Cutting off connections reduces the power required to operate, providing these unused inlets are tightly closed. For this reason it is well to provide cut-off slides in the connections between all machines and the main exhaust pipe so that any idle equipment may be cut out and the power required to operate the exhaust system reduced. Also, care should be taken to see that no small openings or leaky joints are permitted in the branch or main exhaust lines as each adds to the load on the system.

While it is always desirable to remove dust at its source, when possible, there are cases where it is not practicable to do this, as in certain kinds of sandblasting work. When this operation is performed on small articles, the sandblast is usually placed in a box where the operator holds the work in the desired position and watches it through a window. Air is exhausted from the top of the box and the fresh supply for replacement is drawn in through the hand holes.

In the case of larger work, where more space is needed, the whole apparatus is located in a small room, with the blast under a hood exposed to a strong exhaust. Generally the work is placed on a bench with a grating on top which is also connected to an exhaust. Fresh air is drawn in at the rear, as shown in the sketch on page 323, and tends to carry all dust away from the workman and into the hood or down through the bench. This same general scheme is often applied to other kinds of work where operating conditions are much the same.



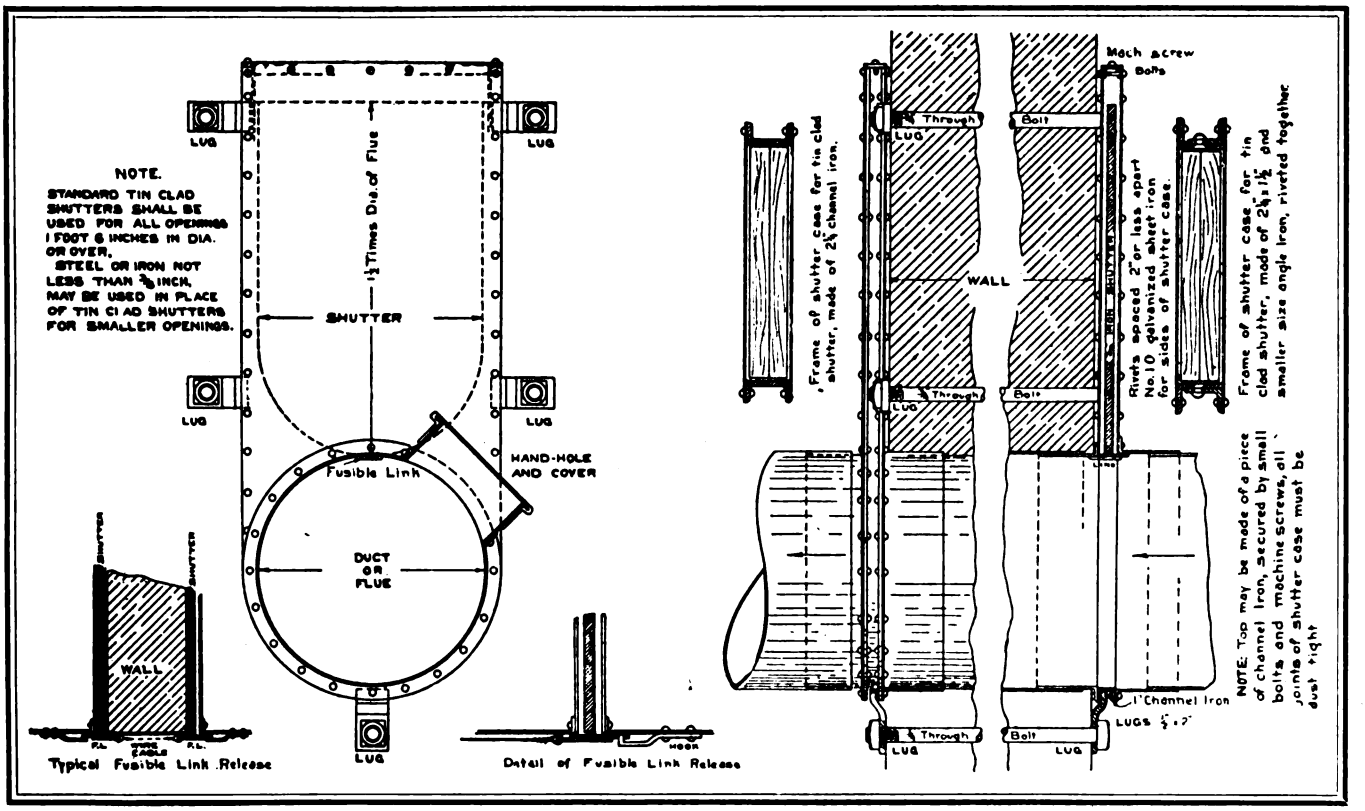
Whenever possible, it is always best to remove dust at the source before it escapes into the room.
Here a special suction line is connected to the working hood of a stone cutting machine in a marble works. The flexible hose allows the machine to be moved about easily. As this dust is heavy and would have an abrasive action on the fan, it is removed through the special collector shown before it enters the fan.

Several industrial plants build workbenches with gratings and a suction in the top. These are used particularly for working on brass and other castings. In this way the dust is drawn down and away from the worker, as produced. In other cases a suction hood is placed beside the work. One of the illustrations shows such a hood beside a bench used for cleaning furs. The furs are gone over by a small suction cleaner as shown and any dust or hair escaping is drawn away from the operator through the hood.

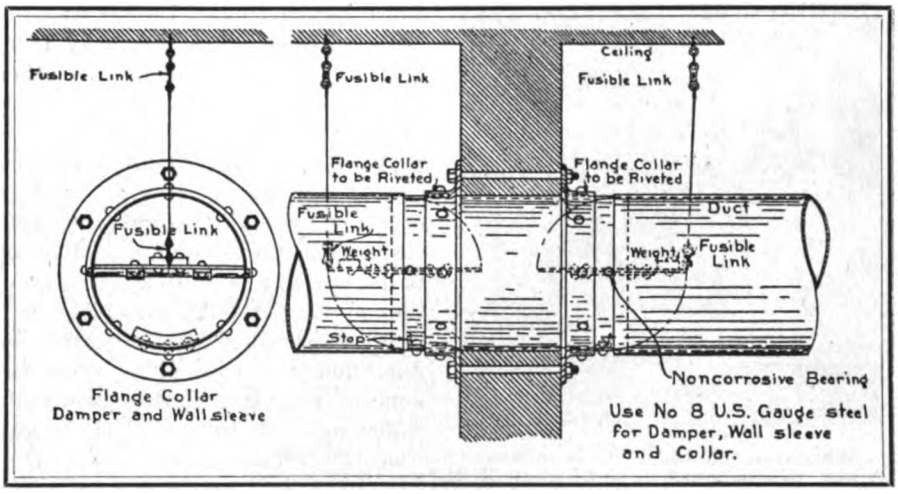
Where the dust particles are very fine, and not especially irritating, general room ventilating is usually sufficient, and this method is also used to a certain extent, even where suction hoods are applied at the source, to remove the dust which escapes these and passes into the air of the room.

While in most plants one or more central or departmental exhaust systems, each connected with a single fan, are employed, there are cases where individual units, or a number of small group systems are used economically and equally effectively. This generally occurs in establishments where there are compara-

A suggested type of vertical duct shutter for openings in fire walls.
Exhaust systems which gather lint or inflammable dusts may be provided with a vertical duct shutter where they pass through fire walls to prevent the passage of a fire from one part of the building to another. This shutter and the two devices on the following page are recommended by the National Fire Protection Association.



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Where the duct opening through fire walls is not over 12 in. in diameter automatic dampers such as these may be used.

Here dampers are placed in the pipe on each side of the fire wall and have fusable links both outside the duct and inside so as to drop the damper in case of a fire either within the room or within the duct.

tively few machines requiring dust removal and where these are located at wide intervals.

Pneumatic Sweeping and Cleaning of Plant and Machines

Removal, after the dust has settled upon the walls, floor, and on objects in the room, including the machinery, requires pneumatic sweeping equipment to secure the best results. This type of equipment is commonly termed a "vacuum cleaner" and consists of motor exhauster, and separator, arranged as shown in an accompanying sketch on page 321. The inlet to the separator is connected with a system of piping extending to all parts of the building, and provided with outlets for connecting a flexible hose and cleaning tool. The form and size of the tool depend upon the character of the work to be done and the nature of the surfaces to be reached, whether floors and walls or parts of machines and other irregular places difficult of access. When in operation, the exhaust maintains a partial vacuum in the separator, thus drawing in the dust-laden air from the cleaning tools through the system of connecting piping. Dust and air are separated in the tank, the air passing to the exhauster, from which it is discharged outside. A fairly strong suction is required for this work, depending upon the length of the pipe lines and other local conditions. Usually a suction of 6 in. of mercury column or about 80 in. of water is the maximum while 2 in. of mercury, or 27 in. of water is the minimum.

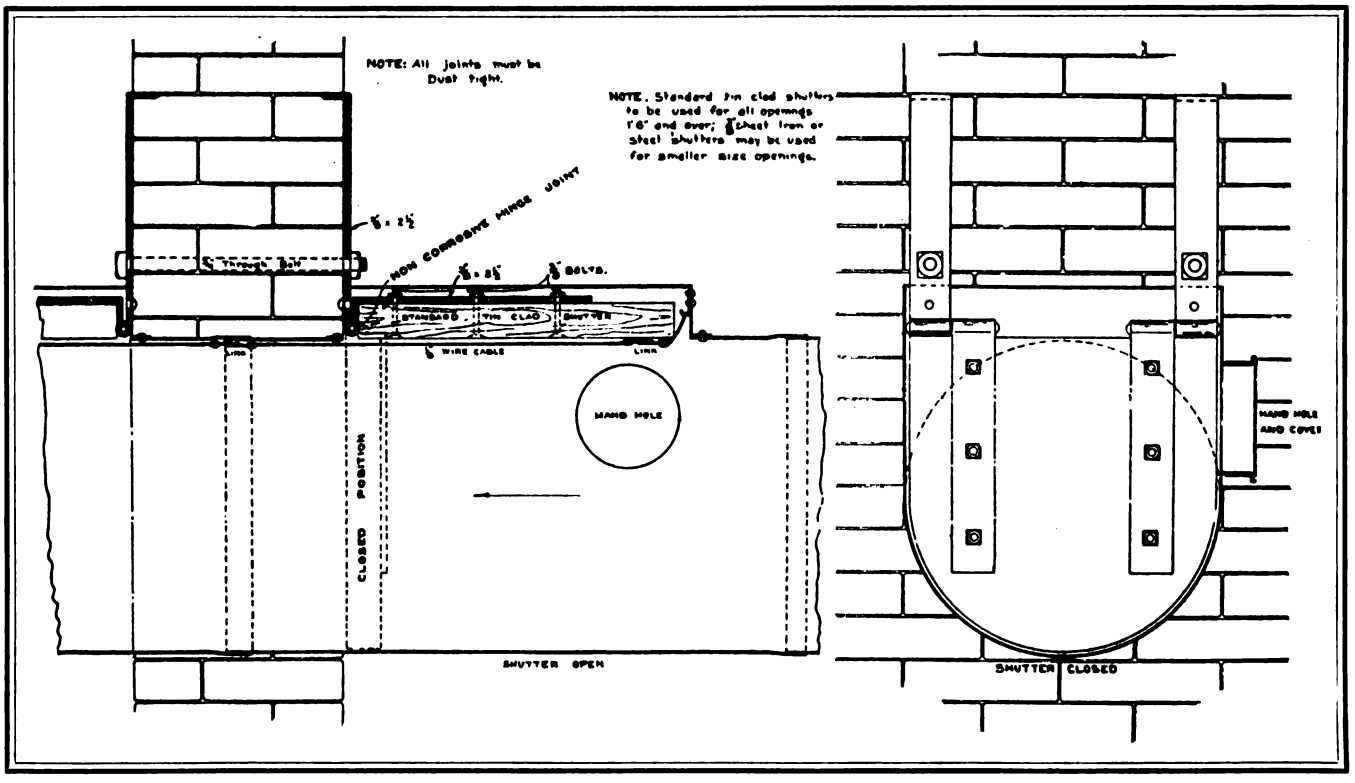
An installation based somewhat on this same general principle is used in the reconstructed Chicago and Northwestern grain elevator to keep down dust accumulation and so prevent another explosion. This system has 408 inlets all over the plant and a capacity whereby 24 men can sweep at a time. Two to three carloads of material are removed daily. This also gathers up any grain, which may drop from the conveyors or otherwise, along with the dust. Grain, however, is separated and saved. Rubber and other plants also employ pneumatic sweeping extensively to remove the dust which settles during the process.

Recent practice makes use of lower pressures than were formerly

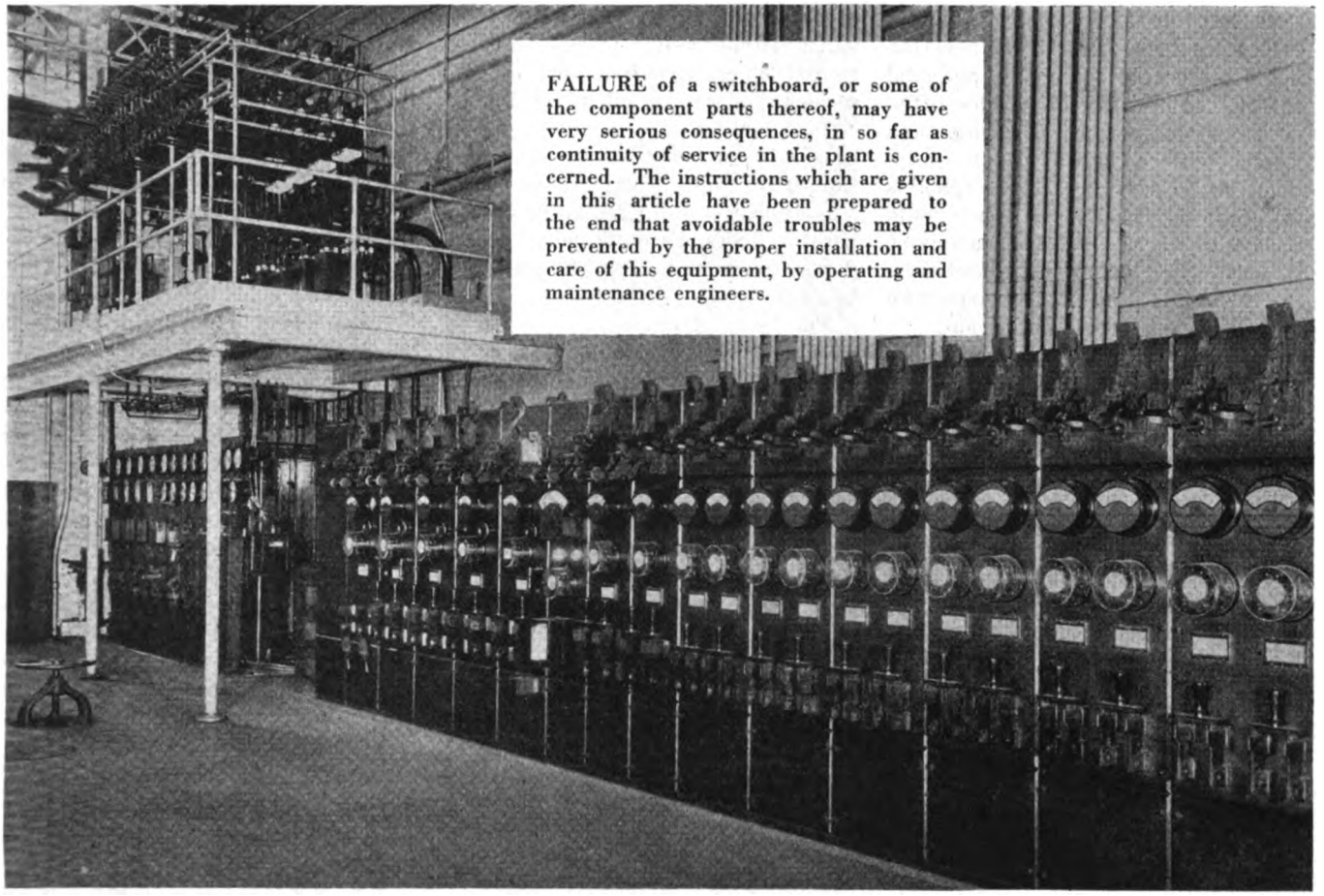
(*Please turn to page 355*)

Another type of automatic hinged duct shutter for openings in fire walls.

This shutter is also used to prevent the passage of fire, which may arise in a duct containing lint or other inflammable material, from one side of a fire wall to another. It is always advisable, if possible, not to extend ducts or other openings through fire walls. However, when such is necessary, devices such as this or the vertical shutter, shown on the preceding page, may be used.



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FAILURE of a switchboard, or some of the component parts thereof, may have very serious consequences, in so far as continuity of service in the plant is concerned. The instructions which are given in this article have been prepared to the end that avoidable troubles may be prevented by the proper installation and care of this equipment, by operating and maintenance engineers.

This illustration shows part of the switchboard in a large steel mill. The feeders from the direct-current board, at the right, are carried up in conduit mounted on the wall behind the board. The oil switches mounted on the platform are controlled from the alternating-current board at the left. Note the method of supporting the buses on a pipe framework, on the platform. Courtesy of The Cutter Company, Philadelphia, Pa.

Recommendations of Electric Power Club on

Installation and Care of Power Switchboards

For the Guidance of Those Who Are Responsible for the Proper Operation and Maintenance of This Important Equipment

INSTRUCTIONS covering the installation, operation and care of power switchboards, oil circuit breakers and switching equipment have been issued under date of May, 1925, by The Electric Power Club, for the use of operating and maintenance engineers.

The Electric Power Club is an association of manufacturers of electric power apparatus and control equipment. The purpose of the organization is to devise standards of practice and construction in the design and application of electrical equipment, and to promote advancements in the production and use of such equipment.

In the introduction to the instructions for the installation, operation and care of power switchboards and switching equipment, the following comment is made:

"The successful operation of power switchboards and switching equipment depends upon proper installation and care, as well as upon proper design and manufacture.

"It is obviously impracticable to give instructions here applying to each of the many devices used to form a complete switchboard. The manufacturer's instructions given with each device should be consulted for detailed information on its installation, operation and care."

The instructions covering power switchboards are substantially as given below. Instructions for the operation and care of oil circuit breakers and switching equipment will be given in a succeeding issue.

Location of Switchboard

The switchboard in the modern power plant is seldom a self-contained device; many pieces of apparatus are necessarily located some distance away from the board proper. The switchboard manufacturer can usually render the customer great assistance in the selection of proper location, if drawings or sketches of the station are given to the manufacturer when placing the order. It is also safe to say that with full knowledge of the available space and conditions, a better or more suitable switchboard can be made. Details can, without affecting cost, be adapted to conditions.

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In settling the location of switching equipment, first consideration must always be given to personal safety. Continuity of service often demands inspection, cleaning, and repair with a minimum of equipment out of service. Ample space is the best safeguard. Aisles should always be liberal, and particularly so if used when operating disconnecting switches, and when inspecting and adjusting other equipment.

Before attempting to install the switchboard the purchaser should make himself familiar with the regulations of the National Electrical Safety Code, The Electric Power Club's safety standards, and any local rules that may apply. Where local rules affect the design of the switchboard, the purchaser must bring such rules to the attention of the manufacturer before the switchboard is designed.

Mats of good quality rubber or other insulating material may be placed in front of the board and in the aisles, as a further protection to the operators.

Switchboard equipment designed for indoor installation must not be exposed to excessive moisture such as driving rain or condensation drop. It must be installed in a dry place, kept at a uniform temperature, and free from corroding fumes and abrasive dust. Any contemplated deviation from this rule should be referred to the manufacturer for advice. In locating the switchboard, precautions should also be taken to guard against strong drafts carrying the arc from air circuit breakers to ground.

Rheostats and resistances should be located so as to obtain sufficient ventilation, and so that one cannot transmit heat to another or to other apparatus.

Provision should be made for space for future growth, so that additional equipment can be installed with the minimum interference to service, and with the maximum factor of personal safety.

Erection of Panels

The switchboard is usually erected on a sill of 6-in. channel iron or 2-in. by 7-in. hard wood, carefully leveled and bolted to the floor after the panels, or at least the panel supports, have been erected on it. The channel sill should also be grouted to the floor by pouring thin concrete into it from the ends and through holes in the top, either before or after the erection of the panel frame. The panel frame is held by bolts tapped into the channel sill, or by lag screws if a wooden sill is used.

The method of anchoring panel braces is dependent on the construction of the wall. Heavy panel equipment requires solid fastenings. Expansion bolts, through bolts, or an angle iron bolted along the wall may be used.

The panel frame may consist of 1¼-in. upright pipe supports, angle irons, or channel irons for exceptionally heavy equipment.

Regardless of the frame construction and the method of shipping panels, whether assembled or dismantled, the middle panels should be erected first, and plumbed and braced securely. If the supports are shipped separately the framework should be set up and plumbed first, then the panels bolted to it, first loosely to avoid cracking, and then securely. Flexible washers must be placed between the frame and the panels. If shipped on its supports, each panel will be set up adjacent to the fixed panel and anchored in place. Shimming should be done between the sill and bottom edge of panels to plumb the free edge. Sometimes it may be necessary to file the edges of two adjacent panels by means of a hack saw blade inserted between them, in order to fit them closer together.

Benchboards are sometimes shipped assembled, but are more frequently knocked down. When erecting the board, the sills are leveled and bolted in place first; then the framework is set up and anchored to the sills; next the vertical sections below the bench sections are erected, always starting from the middle of the board; and last the instrument sections are set up. The grille or sheet-iron work should be fitted, but is sometimes not bolted into place until after wiring.

Frame Structure

Most of the frame structure other than that supporting the panels is

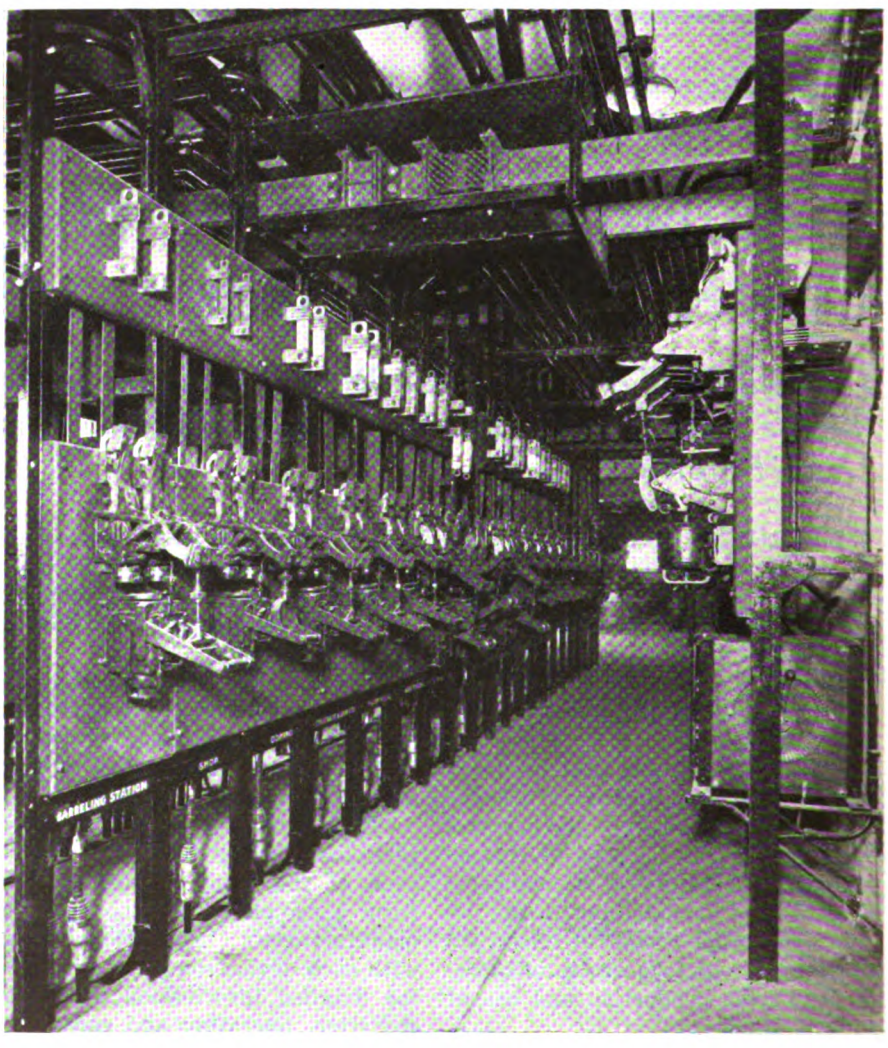


Fig. 1—This shows how the buses and feeders were mounted overhead in an installation in the Baltimore, Md., plant of the American Sugar Refining Co.

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today made of 1¼-in. pipe with threadless fittings, because of its stiffness compared to its weight, its ease of assembling and adjustment, and its attractive appearance.

All such structures should be well braced together to avoid any flexibility that might tend to affect the operation of oil circuit breakers, or transmit jars from them to the panels. The threadless clamp fittings offer in this respect the best facilities for perfect adjustment.

In a heavy-capacity installation complete magnetic circuits should be avoided around a conductor carrying a great amount of current.

The frame must be effectively grounded and the paint removed from the pipes and fittings at the points of contact. There should never be more than three clamped or screwed joints in series for each ground connection.

Pipe caps should be slipped on the exposed ends of all pipes for improving the general appearance of the installation.

All metal work should be painted from time to time for protection and appearance.

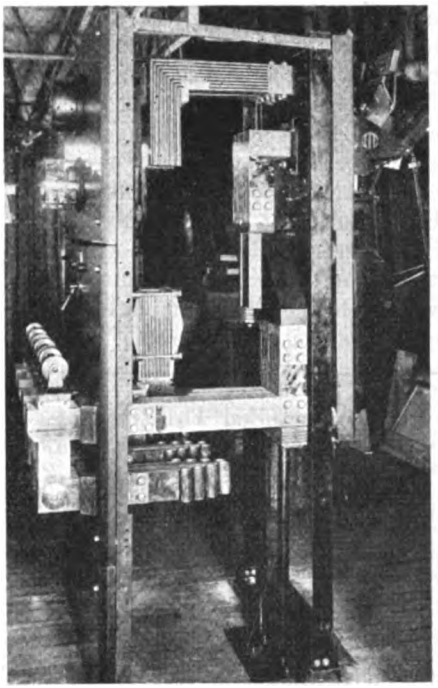


Fig. 2—Here is a neat way of arranging and supporting heavy buses at the back of the board.
Note the cable lugs and bus connections; also, that the angle-iron framework of the board is supported on a channel-iron sill. The circuit breaker which is mounted on a panel at the rear is controlled from the front of the board.

Main Connections

The main connections and the pipe framework may be fabricated, assembled and marked by the switchboard manufacturer. It is then a simple matter to install them by referring to the assembly drawings, which bear detail numbers corresponding to those stamped or stenciled on or tagged to the details. It is important to see that these drawings contain the latest revisions according to the shipping memorandum. When the apparatus is not assembled at the manufacturer's plant, the main connections, as well as the pipe framework, must be made at the point of installation.

Special attention should be given to all joints, whether clamped, bolted or soldered; all contact surfaces must be clean and smooth. Clamping and bolting must be such that the pressure is evenly distributed, and that there is no possibility of the opening of a joint due to vibration or to changes in temperature. This is particularly important where the connections and their joints are insulated after installation. Lock washers and locknuts are sometimes necessary.

It should be remembered that the conductivity of a bolted or clamped joint is proportional to the pressure applied at the joint. A poor joint may heat until the surface is annealed or oxidized, which in turn causes increased heating.

It should be remembered in making soldered connections that the solder has greater resistance than the copper, and therefore will heat if not sufficiently distributed over the entire joint. A heavy overload may cause heating sufficient to melt the solder, and care must be taken that there is no strain or tendency to separate such joints.

Iron clamps with steel bolts may be used in clamping connections for direct-current work, but for alternating-current connections and buses the clamps must be so constructed as to guard against magnetic circuits around individual conductors. This is especially important for heavy currents.

All contact surfaces of buses and copper conductors must be thoroughly cleaned with sand paper and oil immediately before they are clamped together. It is recommended that the purchaser extend this operation to the entire surface of the bars which are not to be insulated after installation, and then give them a coat of transparent lacquer to prevent tarnishing and to preserve a bright appearance. Every trace of oil must be removed before applying the lacquer. It is important that no lacquer should flow on the contact surfaces, and it is, therefore, best to do this work after the joints have been made. When changing buses that have been lacquered, the new contact surfaces should be washed clean with alcohol and then carefully scraped.

There should be uniformity and consistency in the order and arrangement of conductors for the sake of appearance as well as for convenience in caring for the equipment. This should be carried as far as practicable; for instance, on direct-current boards the positive bus and connections may be located nearest the board, nearest the top, and at the right-hand side facing the back of the switchboard. On alternating-current boards, phase 1 may occupy the same position as indicated above for the positive bus on direct-current switchboards.

Complications will naturally arise when the equipment is mounted away from the switchboard. It then becomes necessary to determine how far this uniformity should be carried through the station and to the lines. Local conditions and the size of the power system will be the governing factors in deciding this.

All buses and connections on the switchboard should be designed on the basis of a maximum temperature rise of 30 deg. C. above the room temperature. This limitation, and mechanical stability determine in general the size and shape of switchboard conductors. For the smaller current capacities, round conductors are frequently used as follows:

Conductors for Small Current Capacities

Bare Rod	Maximum Amperes
1/4 in. dia.	75
5/16 in. dia.	150
7/16 in. dia.	200
1/2 in. dia.	300
Insulated Wire	
No. 1/0 A.W.G.	175
No. 4/0 A.W.G.	300

Fig. 3 shows a method of approximating the amount of copper required for heavy buses and connections. Any special conditions should be referred to the manufacturer for advice, with full data on local conditions, because ventilation greatly affects the results.

Rigid supporting of all conductors is necessary, not only for appearance, but also to withstand any electromagnetic stresses which abnor-

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mal conditions may produce. The short circuit force measured in pounds involves several factors, as for instance: the frequency and reactance of the circuit, the spacing and shape of the conductors, the construction of the supports, etc. Problems of this nature encountered in the installation of a switchboard should be referred to the manufacturer for advice.

In alternating-current installations, iron parts, such as supports, conduits, floor beams, etc., must not be placed between the different conductors of a circuit in such a manner as to form magnetic loops around a single conductor, and when dealing with capacities of about 2,000 amp. and above, care must be taken to avoid large masses of iron in close proximity to the circuit, as otherwise the iron will heat. This applies even to reinforcing material in concrete compartments.

Secondary and Small Wiring

All secondary connections from current and potential transformers to instruments should be metallic; the use of the earth as one of the conductors is in general not permissible.

Metallic conduit is recommended for all instrument and control leads between switchboards and other equipment, but care should be taken that all leads of one circuit are placed in one conduit. Control leads should not be placed in the same conduit with secondary leads; it is well to make provision so that any reasonable repairs or changes can be made without jeopardizing the continuity of service. If the secondary and control leads do not run beyond the switchboard room, they frequently enter the switchboard through conduits overhead; otherwise the best practice is to imbed the conduits in the switchboard floor, terminating about 2 or 3 in. above the finished floor, and as close to the terminal boards as possible. The top of the conduits must be provided with bell mouths or bushings to prevent injury to the insulation on the wires. The openings should be filled with wooden plugs or oakum after connections have been made.

The inside diameter of the conduit should be 30 to 35 per cent larger than the cable used in it. Uniformity of size, even if larger than necessary, is an advantage in appearance, as well as in purchasing the material. Sharp bends in the conduit must be avoided and the number of bends between outlets should be held down to not more than three or four. During construction work all conduit ends should be sealed by corks or wooden plugs until the cables are pulled in. Joints should be water tight, particularly if laid in concrete, and provision should be made for drainage to eliminate any water that may accumulate due to condensation or accidents. All conductors of a single-phase or polyphase circuit must be run in the same iron conduit; or fibre conduit may be used for individual conductors. A wire or steel tape should be used in pulling the cable through the conduit. This work is materially lessened if talc or soapstone powder is blown into the conduit or dusted on the cable. It is very important to clean the inside of the conduit before putting the cable through.

Recommended Thickness of V. C. Insulation on Conductors

Voltage Range	Number of Layers
0- 1,000	3
1,001- 2,000	4
2,001- 3,000	4
3,001- 4,000	5
4,001- 5,000	6
5,001- 6,200	7
6,201- 7,600	8
7,601- 8,800	9
8,801-10,000	10
10,001-11,600	11
11,601-13,400	12
13,401-15,400	13
15,401-17,400	14
17,401-19,400	15
19,401-21,200	16
21,201-23,200	17
23,201-25,000	18
25,001-26,800	19
26,801-28,000	20
28,001-30,400	22
30,401-32,800	24
32,801-35,200	26
35,201-37,600	28
37,601-40,000	30

NOTE: This table is based on the use of 0.010- or 0.012-in. varnished cambric.

Another method of entering the board from below is to let the conduits terminate in a trench just back of the switchboard sill. Insulating bushings, through which leads are brought up to the board, are set in a plate projecting slightly over the switchboard side of this trench. Removable plates cover the trench. This arrangement permits a certain amount of crossing of leads out of sight, so that they can be brought up to the board immediately below the terminal points. To make the connections easier, multi-conductor cable is usually furnished with different-colored braid on each conductor.

Solid wire may be used with flameproof covering for exposed wiring on the back of the switchboard, and on the framework. A fixed order of leads is followed as far as practicable in cleating wiring to the panels; for instance, for each panel or circuit the current leads may be brought up at the left side facing the rear of the switchboard, the potential to right, and the control leads in between.

No bare connections above 750 volts should be allowed in the switchboard room, or where connections are accessible from the aisles. Connections for about 11,000 volts and above are usually so far out of reach as to be harmless, and so well protected by space insulation as to preclude the necessity for wrapped insulation. The switchboard manufacturers cannot furnish these connections insulated because the taping should be continuous over the connections and the terminals or lugs. This is considered part of the installation material. It is also recommended that the purchaser insulate all connections and terminal lugs for circuits below 750 volts in which enclosed switches or oil circuit breakers are used. While a lever switch with bare live parts is in itself a caution notice, a device such as an oil circuit breaker, being enclosed, inspires confidence and invites dangerous contact with terminals and connections. It should, of course, be borne in mind that a carefully wrapped conductor may not be safe to handle alive.

In general, connections installed in compartments and those operating at 15,000 volts and above are not insulated. Since insulation has a tendency to increase the temperature rise of a conductor, the purchaser should not insulate connections designed to be left bare without first consulting the manufacturer.

The proper thickness of insulation for different voltages based on the use of 0.010-in. or 0.012-in. varnished cambric is suggested in the accompanying table. Over the outside layer of varnished cambric there should be applied cotton tape half-lapped and finally two coats of flame-resisting paint.

Ground Connections

A good and reliable ground connection is very important for every

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switchboard installation. It should be of sufficient capacity to take care of any abnormal conditions that may occur on the system, and it should be independent of the grounds for lightning arresters and other power apparatus.

The secondary windings of all current and potential transformers should be connected to ground at the transformers and without fuses. If for any reason this cannot be done, as for instance with instruments and meters having secondary current and primary potential coils, the secondary wiring must be insulated and installed to withstand primary potential with safety.

All metal conduits should be grounded.

The switchboard frame should be grounded at every upright support, and care should be taken to remove the paint on fittings and pipe to permit a good connection. The channel sill should be grounded in this manner by a perfect contact with the supports.

Exceptions—An insulated frame should be used for single-polarity, direct-current switchboards of 700 volts or less with grounded negative.

Switchboard devices for operation at 150 volts or more above ground potential should have their exposed metal frame parts permanently grounded when these are insulated from the current-carrying parts and not isolated by elevation or otherwise permanently protected. This rule covers, for example, transformers and alternating-current instrument casings, operating mechanisms for switches and oil circuit breakers, oil circuit breaker frames, rheostats, compensators, etc. This is usually accomplished by connection to ground buses, of a cross-section not less than No. 2 A.W.G., which should run the entire length of the switchboard, and the oil breaker structure, if the two are separate.

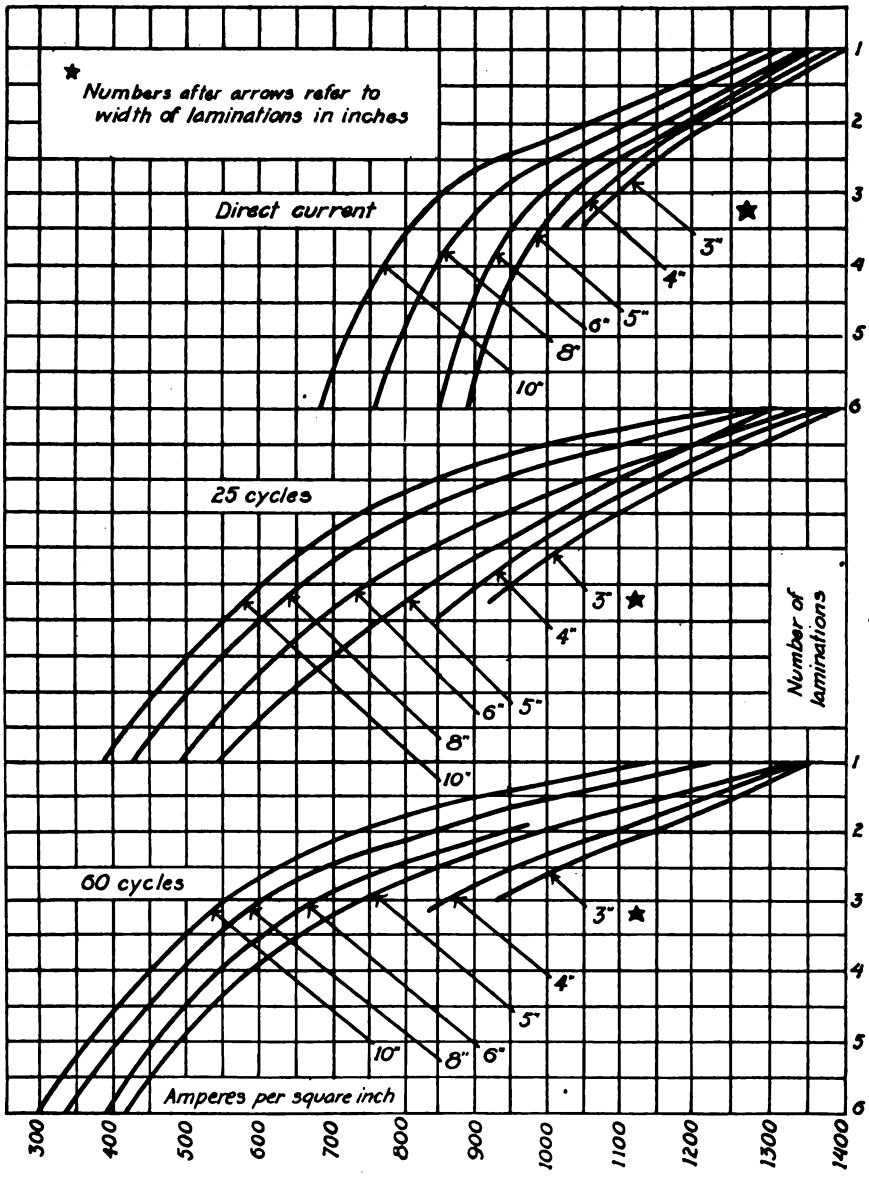


Fig. 3—Current-carrying capacity of usual sizes of copper buses.

These curves refer to buses composed of laminations ¼ in. thick with ¼-in. spacing between laminations, and an allowance of 8 in. between phases. The values given may be used for currents not exceeding 3,000 amp., and are based on a 30-deg. C. rise at an ambient temperature of 40 deg. C. The use of two ⅛-in. thick laminations in place of one ¼ in. thick strap gives increased capacity due to increased radiating surface. However, this advantage is gradually offset by inductance as the number of laminations per phase increases and as the spacing decreases.

Steel work and frames for high-voltage switching equipment should be grounded at several points to guard against insulation at the joints. There should never be more than three clamped or screwed joints in series for each ground connection, and for high-voltage apparatus there should be less.

There are various methods used to secure a ground connection. One plan is to drive galvanized iron pipes of about ¼ in. diameter into permanently moist earth, spacing them about 8 ft. apart along the side of the station, and joining them together by a copper strip about 1 in. by ⅛ in. The pipes should be kept filled with rock salt. The ground connection should be made to this system of pipes at two or three points, and all joints riveted and soldered, or brazed.

Another method in many cases preferable is to bury a copper plate, about 3 ft. square, in permanently moist earth with a layer of crushed coke or charcoal about 2 ft. deep, both below and above it. The ground cable, which should be riveted and soldered across this plate, should be brought into the station and securely connected to the different ground buses.

Work on current-carrying parts should not be undertaken until these parts have been disconnected from the system and connected to the ground bus. Provision should be made, therefore, by the purchaser for connecting flexible ground leads so as to reach every part of the switching equipment.

Illumination of Switchboard

The switchboard should be amply illuminated both front and back by the station lighting system, and it is well to provide some emergency system so that the switchboard room cannot be put in darkness under any abnormal condition. In stations with storage batteries, this can be accomplished most easily by means

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of automatic throw-over switches, which, on failure of the normal lighting circuit, throw a number of lights on to the battery.

Phase Rotation

A method which is often most convenient for testing out the connections for phase rotation is to use a small induction motor connected to the line or to the machine direct, or through potential transformers. Another simple method is that shown in Fig. 4. One of the lamps will glow more brightly than the other. If lamp *B* is brighter, phase rotation is clockwise, or 1, 2, 3. If, on the contrary, lamp *A* is the brighter, phase rotation is 3, 2, 1, or counter-clockwise. It is always a wise plan to study carefully the instructions sent with the machine before connecting it up for operation.

Synchronizing

The following instructions serve for testing the connections of the synchronism indicator or synchroscope, and for emergency conditions. Unless the two polyphase circuits have already been running in parallel, so that there is no question about the sameness in phase rotation, two phases should be checked. Connections may be made as in Fig. 5 with the circuit breaker open. When the electromotive forces of the two sources are exactly equal and in phase the current through the lamps is zero. As the phase difference increases, the lamps light up, and at 180 deg. out of phase they will all burn with full voltage. The rate of pulsation of the lamps depends upon the difference in frequency of the two polyphase circuits. So far it has been assumed that the phase rotations of the circuits to be synchronized are the same. However, should the two sets of lamps, the lamps in the two phases, not pulsate in unison, it is safe to say that the phase rotation of the two sources is not the same, and changes should be made in the order of the main connections until the desired indication is obtained.

Only one set of lamps is necessary for single-phase circuits, as there is no question of phase rotation. The method just described here is termed synchronizing with dark lamps. To determine whether the lamps will be dark or bright for a given synchronizing connection when the machines are in phase, the main leads should be disconnected

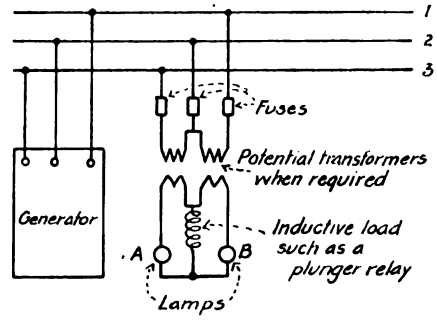


Fig. 4—Here is a simple method of determining phase rotation.
With the connections shown one of the lamps will be brighter than the other. If lamp *B* is brighter than lamp *A*, phase rotation is 1, 2, 3, or clockwise. If lamp *A* is brighter, phase rotation is 3, 2, 1, or counter-clockwise.

at the generator and the circuit breaker closed. Since both circuits are then connected to one source of power, the lamp indication will be the same as if the circuit breaker were open and the separate sources of power were in synchronism.

It is extremely important in all such synchronizing connections that the indication represent the condition of the circuits at the circuit breaker, which is to parallel the circuits. In other words, if there are transformers in one of the circuits to be synchronized, they must be outside the synchronizing connections, as in Fig. 5, otherwise there is a danger of there being a synchronous indication while the circuits are in direct opposition.

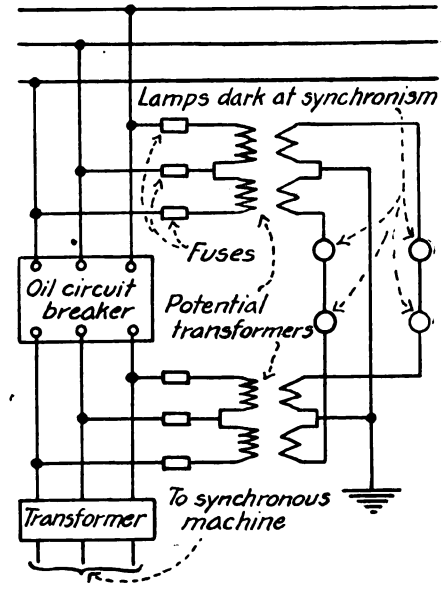


Fig. 5—Method of synchronizing with dark lamps.
The connections of the synchronizing device should be made as indicated, with the circuit breaker open. When the two circuits are 180 deg. out of phase, the lamps will glow with full brilliancy. Assuming that the voltages of the circuits are equal, as the phase difference decreases the brilliancy of the lamps will decrease so that when the circuits are exactly in phase the lamps will be dark.

Ground Detectors

It is frequently necessary on ungrounded systems, alternating current as well as direct current, to install some kind of equipment for detecting or reading leakage to ground. The simplest method for low voltage, two-wire systems is to connect two lamps of the system voltage in series across the two wires, with the connection between the two lamps grounded. A ground on one side will obviously short-circuit and darken the lamp on that side. A static or glower type of ground detector instrument is generally used for voltages above 300.

Operation

Inasmuch as the switchboard controls all of the machinery and other apparatus in the station, it is most essential to its proper operation that the operator become familiar with all general and special instructions referring to the apparatus.

Before putting the switchboard into service, all connections to instruments, meters, relays, etc., should be carefully checked with the drawings and care should be taken to see that resistances are connected in all the meter and instrument circuits requiring them. A preliminary trial should then be made to see that the instrument and meter equipment reads or records in the proper direction. In fact, before putting a switchboard into actual service, it is advisable to put current through all parts at reduced potential in order to bring out any weak spots. The potential and load can then be slowly increased to normal.

Every detail should be closely watched, and anything out of the ordinary should be carefully noted and investigated. The switchboard manufacturer invites information on the behavior of the equipment, and welcomes opportunities to assist with advice. Any defects discovered should be reported to him immediately.

Before each starting of the plant, be sure that all switches and circuit breakers involved are open and that no other device is in such condition as to cause trouble when throwing potential on the switchboard. After everything is adjusted and running, the instruments should be read regularly to see that no device or

(Please turn to page 350)

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Methods of

Taking and Recording Rewinding Data

On D. C. Armatures so That All of the Details of the Winding Will Be Noted in Such a Manner That Any Winder Can Use the Data

By A. C. ROE

Renewal Parts Engineering Department, Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.

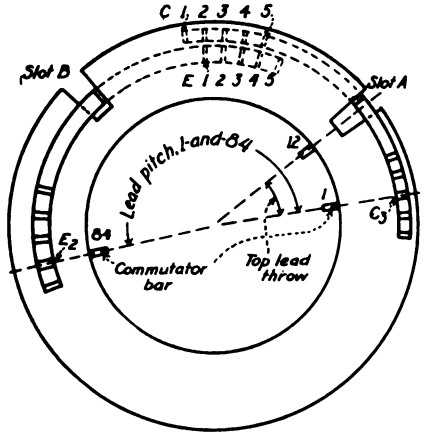
IT IS VERY easy to leave out some important detail when taking the data on an armature that is to be rewound. This is particularly true in the case of direct-current armatures, for in addition to the data concerning the coils, data must be taken in connection with the commutator. This is the second of a series of articles on this subject by Mr. Roe. The first article was published in the June issue and gave some of the more simple methods that he has found to be of value. This article describes some rather elaborate forms which may be useful in your repair shop.

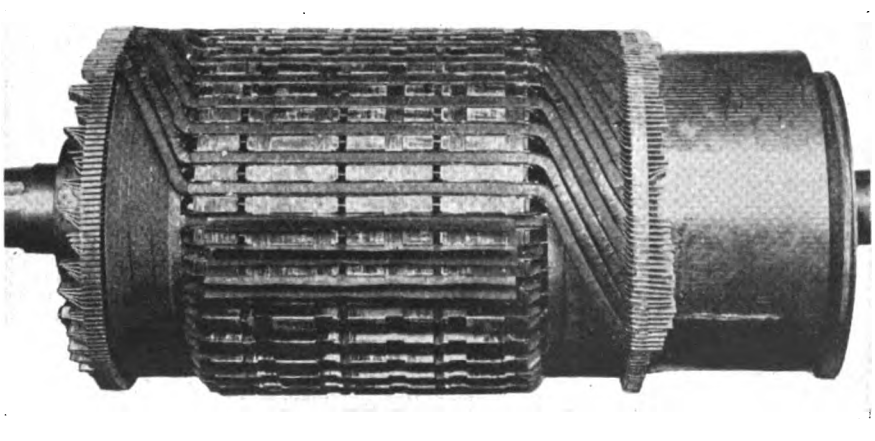
TAKING the rewinding data on the armatures of direct-current motors is a very important part of the motor repair job if the repaired armature is expected to duplicate the performance of a new one. If an important detail is incorrectly recorded or omitted, costly mistakes may be made in rewinding the armature. To insure that the data are completely and correctly recorded, a systematic method of taking and recording them should be followed. In the June issue of INDUSTRIAL ENGINEER, details of three methods of taking these data were given. The first of these methods is very simple and will undoubtedly fill the needs of a small repair shop handling a limited variety of motors. The second method is more comprehensive in scope and will meet the needs of many larger shops. The third method is very complete and covers practically all of the more usual types of direct-current armatures.

There is no one best method that can be used for all kinds of windings. One method is sometimes more suited to one type of winding than to another. However, another method may be more easily understood by the men who have to use it. It is for this reason that in what follows several other methods are given, which many winders will undoubtedly desire to use.

In the forms that were described in the preceding article the lead throw was counted from, or based on, the center line of the slot that holds the bottom coil side. In other words when taking the data on a winding, the slots containing the top and bottom coil sides of a selected coil were first located. The slot holding the bottom coil side was called slot *1* and this slot was used as a base in determining the number of the slot holding the top side of the coil. Next was found the commutator bar to which the lead from the bottom coil in slot *1* was connected. This bar was called bar *1* and, counting from this bar as a base, the bars connecting to the top coil side and also the bar or mica between two bars which were in line with slot *1*, were located. From this the coil throw, lead throw, and the lead pitch were found.

In Fig. 3 are shown forms for recording rewinding data, which use the center line of the coil as a base in determining the lead throw, instead of the center line of the slot containing the bottom coil side, as was the case in the preceding article. Diagram *A* shows a winding unit having five coils per cell. The center of this winding unit or bunch of coils falls on slot *4* and also on commutator bar *32*. In determining the lead throw, the center coil of the winding unit is used as a base, as is





Figs. 1 and 2—Method of taking data on strap-wound armature.

Inspection of the diagram and the illustration of the armature that it represents will show that each slot contains two half-coils or winding units, each of which consists of five straps. *C1*, *C2*, *C3*, *C4*, and *C5* are the top straps, and *E1*, *E2*, *E3*, *E4* and *E5* are the bottom straps. The inner circle represents the commutator. The important thing to know is which top strap connects at the rear to a given bottom strap. In the winding shown the strap *C3* from slot *A* is connected at the rear to strap *E2* from slot *B*. The front end of strap *C3* is connected to commutator bar *1* while the front end of strap *E2* is connected to bar *84*. Consequently, the lead pitch is said to be 1-and-84, C3-E2. Commutator bar *12* is directly under the center of slot *A*; hence the top lead throw is said to be 1-and-12.

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shown in the diagram. Counting from the adjacent bar to the one on which the center line of the coil falls, we find that the center lead from the bottom coil side falls on a bar which is 31 bars away from the reference bar in line with the center of the coil. The same is true for the center lead of the top coil side. The bars may be numbered as given, or better, the bar connecting to the center bottom lead may be called bar *1*, the bar on the center line of the coil may be called bar *32*, and the bar connected to the center top lead may be called bar *63*. This is indicated in the diagram.

In *B* of Fig. 3 is shown a similar diagram for a coil, the center line of which falls on a tooth and upon the mica between two bars. It also shows the manner of indicating a dead coil.

In *C*, *D* and *E* of Fig. 3 are incorporated all the good points of the preceding data forms. Diagram *C* is for lap windings while *D* and *E* are for wave windings. In each of these three diagrams it will be noticed that two arrangements of slots are shown. The top arrangement is for use when the center line of the coil falls on the center of a slot, while the lower arrangement is used when the center line of the coil falls on the center of a tooth. In each case the slot marked *A* is taken as the slot holding the bottom coil side and is called slot *1*. Slot *F* locates the center of the coil if the coil center falls on a slot; if it falls on a tooth, slots *E* and *D* locate the coil center. Slot *B* holds the top coil side.

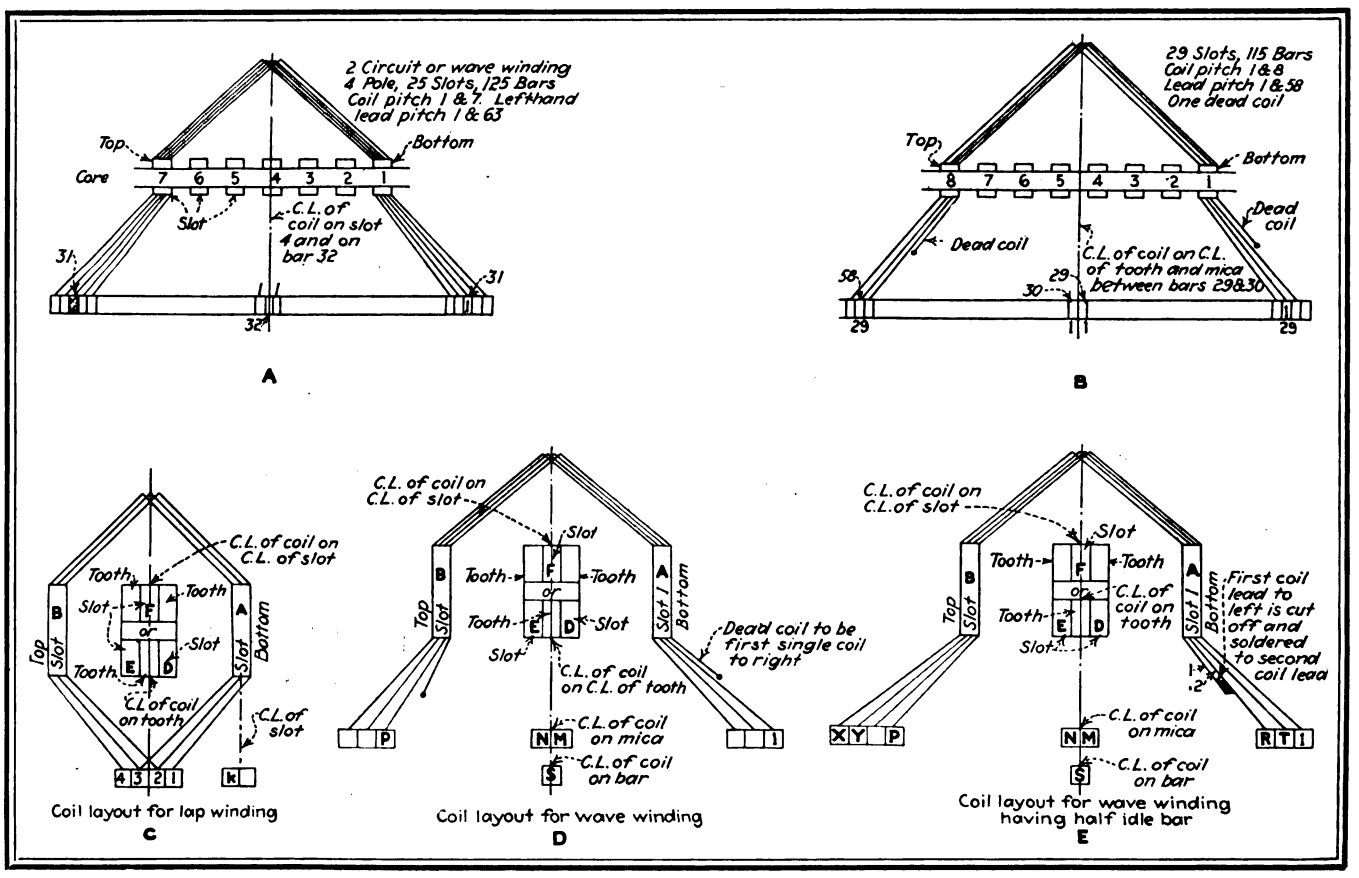
In diagrams *D* and *E* provision is made for when the center line of the coil falls on the bar, as well as when it falls upon the mica between two bars. Bar *S* is located in the former case and bars *M* and *N* in the latter.

Diagram *D* also shows the method of indicating a dead coil while diagram *E* gives the method of showing a long-jumper connection, which was described in the preceding article on page 284 in the June issue.

Fig. 3—Data forms that will give the winder exact information for locating the commutator, core, and coils with respect to each other.

In diagrams *A* and *B* is shown a method of taking rewinding data using the center of the coil as a reference point in locating the slots holding the coil as well as the bars to which the leads of that coil are connected. In *C*, *D* and *E*, this idea has been followed out more elaborately. These diagrams will take care of cases in which the center line of the coil falls upon the center of a tooth or upon the center of a slot, as well as when the center of the coil falls on a bar or on the mica between two bars. *C* is for use with lap windings, while *D* and *E* are for use with wave windings.

Figs. 4 and 5 show another method of taking the rewinding data. The form used is quite elaborate. Diagram *A* of Fig. 4 shows the data as taken for an armature having 39 slots and 195 commutator bars. In taking these data, a coil was selected and the bottom and top coil sides were located. The slot holding the bottom coil side was called slot *1* as shown in the diagram and counting from this coil side to the slot holding the top coil side, the latter slot was found to be slot *11*. The slot in line with the center of the coil was found to be slot *6*. The center line of slot *6* was found to line up with the mica between commutator bars *48* and *49* as shown in diagram *A*. The numbers of these commutator bars were found by taking as bar *1* the bar to which the first lead of the bottom coil side in slot *1* was connected. Likewise the bar to which the corresponding lead of the top coil side was connected, was found to be bar *98*. The commutator bars to which the leads of this winding unit are connected, are punch marked as shown in the diagram. To distinguish the bars to which the leads of the top coil side are connected, the group of bars to which these leads are connected are marked with an extra punch mark, as shown. Also the bars that are in



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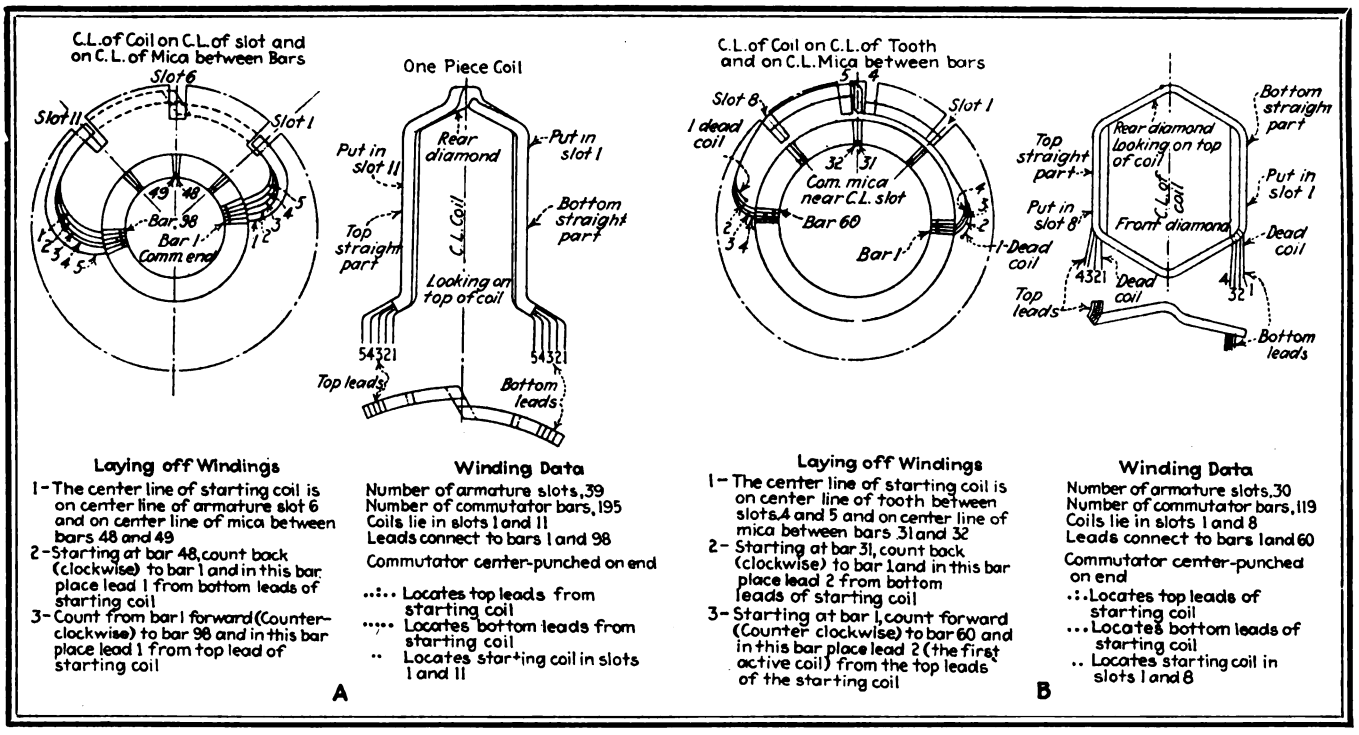


Fig. 4—This method of taking data gives the winder a true picture of the coil in the slots, showing the relationship existing between core, coil and commutator.

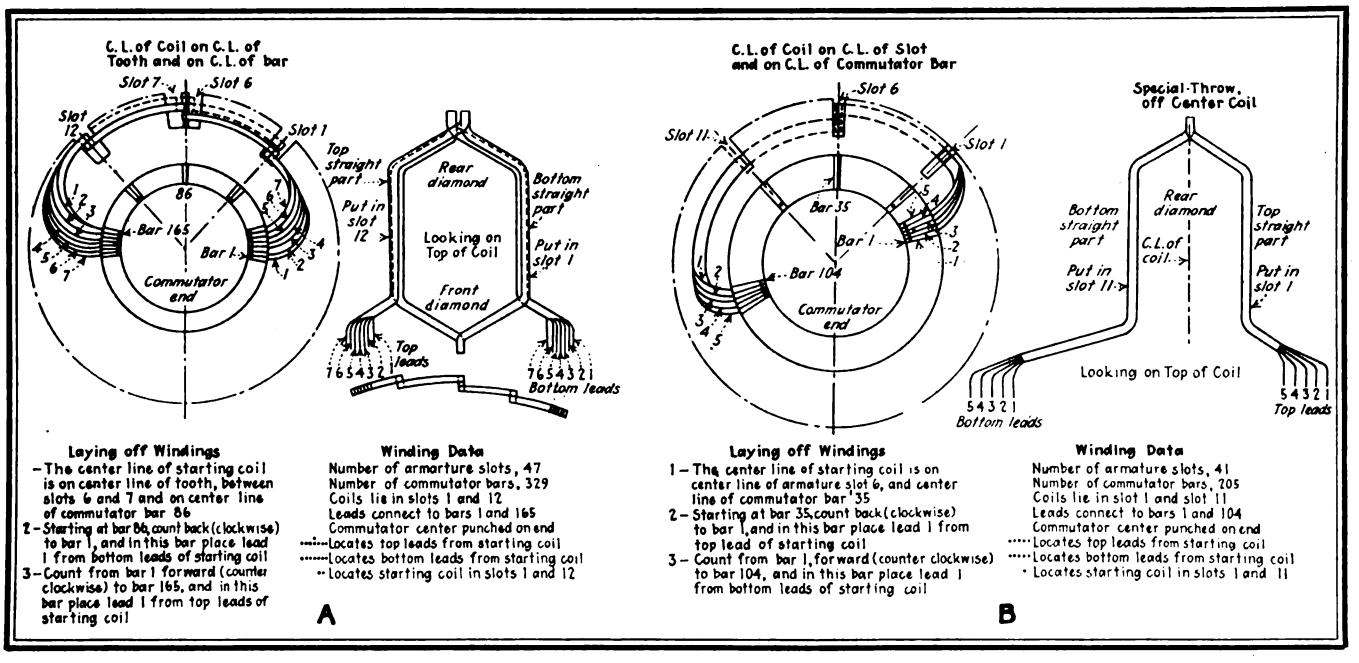
With this method of recording the data four cases arise. One is where the center line of the coil falls on the center of a slot and also on the mica between two commutator bars, as shown in diagram *A*. Another is when the center line of the coil falls on the center of a tooth and on the mica between two bars, as shown in diagram *B*. The other two cases are illustrated in *A* and *B* of Fig. 5. In diagram *A* is shown a winding unit having five coils. The one shown at *B* has four coils, one of which is a dead coil.

line with slots *1* and *11* are punch marked so that the starting coil slots will be located with reference to the commutator. These punch marks eliminate the chance of getting a retrogressive winding in place of a progressive winding or vice versa. The procedure in laying off the winding from the data is given in the notes under the diagram.

Four different types of blank forms are required if this method is used. One should be made up similar to *A* of Fig. 4, in which the center line of the coil falls upon the center line of a slot and also upon the mica between two bars. Another form would be required where the center line of the coil falls on a tooth and on the mica between two commutator bars. Such a form is shown in *B* of Fig. 4. A third form is required where the center line of the coil falls on the center line of a tooth and on the center of a commutator bar. This form is illustrated in *A* of Fig. 5. A fourth form is required for the case in which the center line of the coil falls on the center of a

Fig. 5—These two forms are used in connection with those shown in Fig. 4.

When the center line of the coil falls on the center of a tooth and on a bar, the diagram shown at *A* is used. This diagram also shows the method of indicating a winding unit having seven, two-turn coils. If the center line of the coil falls on the center of a slot and a bar, the diagram shown at *B* is used. This diagram also illustrates the method of showing a special-throw, off-center coil.



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slot and upon the center of a bar. Such a form is shown in *B* of Fig. 5.

The method of indicating the location of a dead coil on these forms is shown in diagram *B* of Fig. 4. Likewise the manner of indicating a half-idle bar is shown in *A* of Fig. 5. Diagrams *A* and *B* of Fig. 4 show windings having five and four coils per cell, respectively. Diagram *A* of Fig. 5 shows a winding having seven coils per cell. This winding uses a coil that has two turns and is of the type known as double loop roll; that is, the coil has one loop or roll in front and a double loop or crossover at the rear diamond point. The double loop at the rear eliminates crossing the bottom leads over the coil side as the bottom leads are brought out on the bottom of the bottom half of the coil and the top leads are brought out at the top of the top half of the coil.

Many of the larger, heavy-duty motors, particularly railway-type motors, use half coils. In Fig. 1 is shown a diagram for recording the data on windings using half-coils. Such a winding is shown in Fig. 2. In this particular winding it can be seen that each half-coil is made up of five straps that are insulated from each other and assembled as one winding unit.

As can be seen from Figs. 1 and 2, there are two half-coils per slot, one in the bottom and one at the top. In Fig. 1, the top straps in a slot are designated by the letter *C* and the bottom straps in a slot by the letter *E*. Each strap is numbered from *1* to *5*. The inner circle in the diagram represents the commutator. The front end of the second strap in the bottom of slot *B*, that is, the *E2* strap, connects to commutator bar *84*, while the third strap at the top of slot *A*, that is, strap *C3*, connects to commutator bar *1*. The rear end of strap *C3* is clipped to the rear end of strap *E2*. In other words, the two half-coils, *C3* and *E2*, are clipped together at the rear to make a whole coil. The lead pitch will then be seen to be 1-and-84 as measured on the commutator. However, to give complete data on the lead pitch, we must give it as 1-and-84, C3-E2, thereby indicating the "creeping" that takes place. The commutator bar directly under the center of slot *A* is bar *12*; hence the top lead throw is said to be 1-and-12.

We have said that strap *C3* is connected at the rear to strap *E2*. Likewise *C4* connects to *E3*, *C5* connects to *E4*, and *C2* connects to *E1*. Thus we see that we "creep" or advance one strap in going from slot *B* to slot *A*. The effect of "creeping" is somewhat the same as a split pitch.

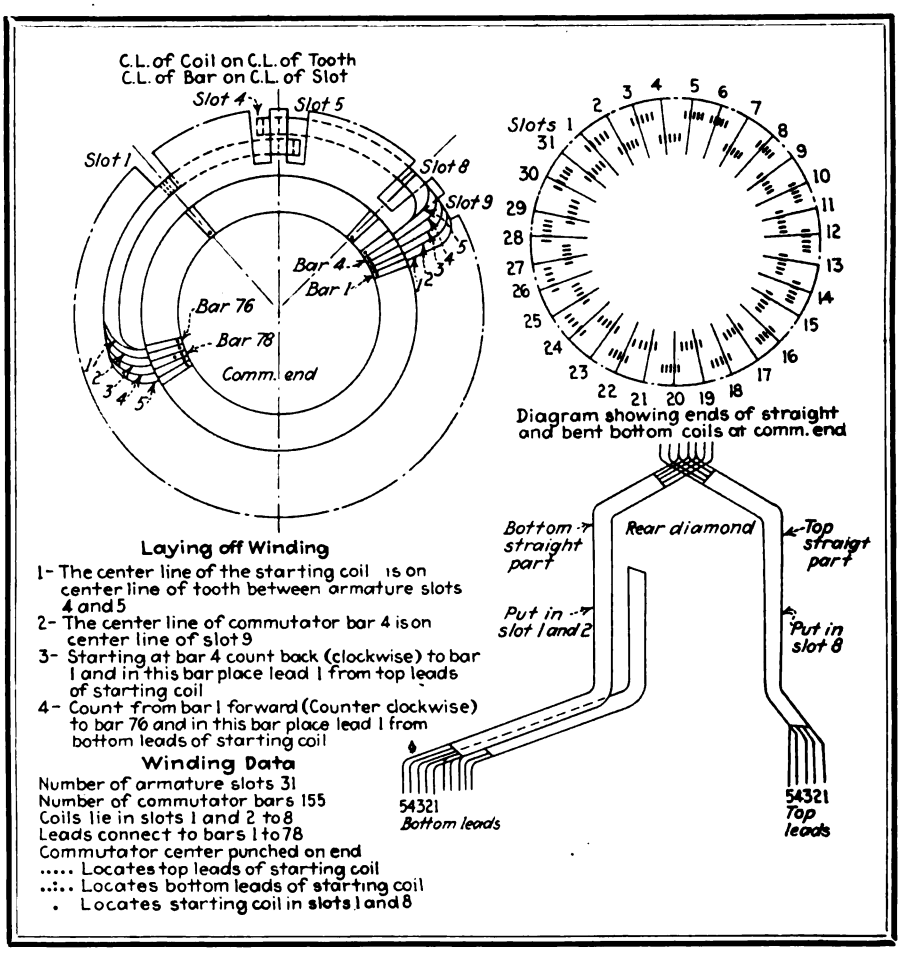
A jig is used in winding strap-wound armatures of this type. This jig is shown at the left of Fig. 2. It has as many slots cut in it as there are commutator bars, the slots being deep enough for two straps plus any fillers or spacers required, including a snug fit for the copper thickness used in the coil. The jig acts as a dummy commutator and lines up the rear end to receive the connecting clips. After all of the top and bottom coils are in place, the coil ends are trimmed off flush with the jig and a band is put over the coil ends near the jig to hold the coils in place while the jig is being removed and during the operation of applying and soldering the connectors. The jig is then removed and the clips are put on and soldered. The advantage in using the jig lies in the fact that the coils are evenly cut off and can be readily connected up. In addition, the armature is easier to balance and has a true line appearance when running.

A more elaborate method of recording the data for a half-coil winding is shown in Fig. 6. In this case the center line of the coil falls upon the center of a tooth. Also, the center line of bar *4* falls on the center of slot *8*. This locates the commutator with respect to the armature slots. The top lead throw, as can be seen from the diagram at the left and from the lower right-hand diagram, is very small—about one slot. Most of the lead throw is in the bottom leads.

This armature has three different shapes of half-coils. There are 31 top half-coils that are all alike. There are also 31 bottom coils, 16 of

Fig. 6—Here is a very elaborate method of recording the data for a winding using half-coils.

The diagram at the left gives the coil pitch, lead pitch and lead throw as well as the relation existing between the core, coil and commutator. The lower right-hand diagram shows the three shapes of half-coils that are used. All of the 31 top half-coils are the same. Sixteen of the bottom half-coils are straight as shown in the diagram while 15 of them have a U-shaped bend at the commutator lead end so as to fit into the winding space available. The upper right-hand diagram gives the location of the straight and bent bottom coils at the commutator end. The inner circle of lines represents the bent coils, while the outer circle of lines represents the straight coils.



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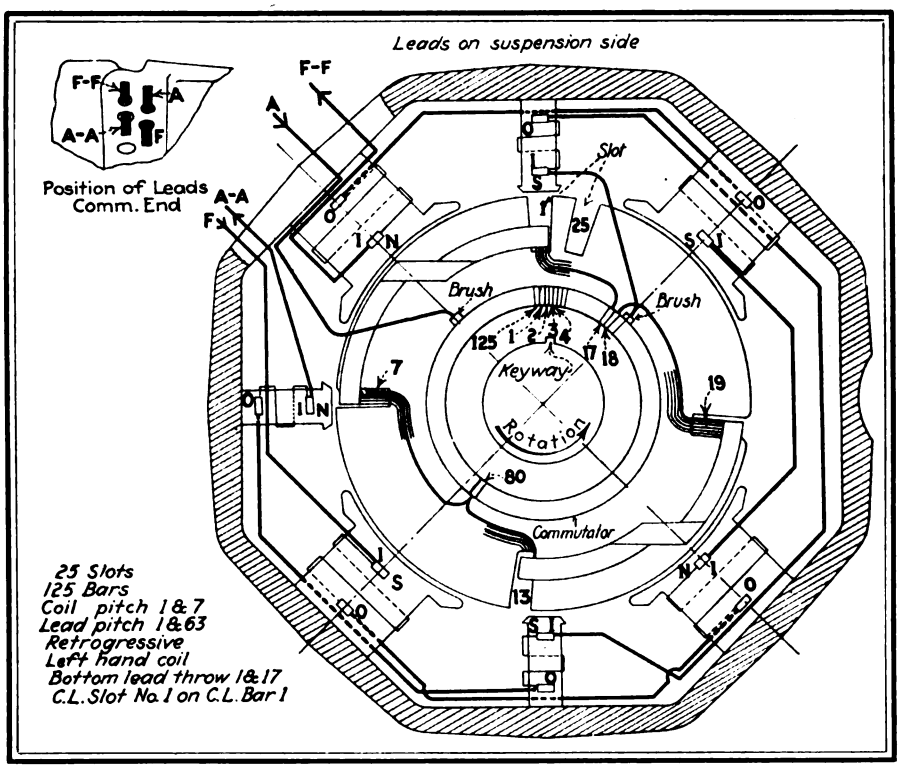


Fig. 7—This form gives all of the electrical connections in the motor.

Not only are the complete armature data given and the winding shown for a series of two coils, but also all of the series field, interpole field, brush, and terminal connections are shown. The starting coil is taken as starting from bar *18*. As can be seen a winding unit consisting of five coils per cell is used. *I* and *O* represent inside and outside terminals of the fields. The inside terminal is the one nearest the air gap. *N* and *S* indicate the polarity of the field poles. *A* and *A-A* are the terminals for the armature circuit which, of course, includes the interpole field. *F* and *F-F* are the terminals of the series field circuit.

which are called bottom straight coils. This term is used to denote that the commutator lead ends leave the armature slot and go to the commutator necks without dipping or bending down and up. There are also 15 bent bottom coils. The term bent indicates that the commutator end of the coils drops below the straight bottom coil, as the bent coil leaves the slot, then bends up again as it enters the commutator neck. The reason for the two kinds of bottom coil sides lies in the long bottom lead throw and the small amount of winding room between the armature core and the commutator, which requires the bottom leads to be put down in two layers.

The upper right-hand diagram in Fig. 6 shows the slots in which the straight and bent coils fall. The inner circle represents the bent coils while the outer circle represents the straight coils.

Inspection of the lower right-hand diagram of Fig. 6 will show that top lead *1* is connected at the rear of the armature to bottom lead *3*; that is, there is a "creepage" of two straps. Likewise top leads *4* and *5* connect at the rear to bottom leads *2* and *3*, respectively. The data in Fig. 6 also indicates that the winding uses right-hand coils.

Fig. 7 shows an extremely elaborate type of data sheet which gives the field connections, the brush position, the direction of rotation of the armature, and the polarity of the interpoles in relation to the polarity of the main field poles, as well as the layout of the armature winding. As can be seen, the first coil starts at commutator bar *18*, goes to slot *19*, through this slot to slot *13*, and thence to commutator bar *80*. The second coil starts at commutator bar *80* and goes to slot *7*, through slot *7* to slot *1*, and thence to commutator bar *17*, one bar behind the starting point. Consequently, the winding is retrogressive.

Inspection of slots *1* and *7* will show that the winding has five coils per cell. Notice that the winding is laid off from the center coil in the cell. Also note that commutator bar *1* is taken as the bar which falls on the center line from slot *1*. Commutator bar *3* falls over the center of the keyway. These data thus locate the position of the core and commutator with respect to each other and to the keyway of the shaft.

All of the connections of the series and interpole fields are given. The polarity of each pole is indicated by *N* or *S* placed on each pole.

The order in which the leads are brought outside of the frame is shown in the small diagram in the upper left-hand corner of Fig. 7. Careful study of this form of diagram will show that all of the electrical connections in the motor are given, as well as the electrical relationship between the various parts.

Succeeding articles in this series will take up in detail the methods used to obtain the winding data and will give rules for the guidance of the winder in taking these data.

Making a Survey of the Power Load

(Continued from page 315)

motor and thus make it run at leading power factor.

The reactive kilovolt-amperes taken by the load shown at *BO* are equal to *BF* or 1,393 kva. This must be reduced by an amount that will bring the system power factor up to 90 per cent as that is the power factor desired. Draw the 90 per cent power factor line, *MO*. *MO* intersects *BF* at *C*. Hence at the desired 90 per cent power factor the system will draw a reactive kva. equal to *CF* or 821 kva. The synchronous motor must therefore supply a leading reactive kva. of *BC* or 572 kva. as well as a true power of *AB* or 642 kw. Hence the capacity of the synchronous motor is represented by *AC* and is equal to 860 kva. It will operate at 74.6 per cent leading power factor. The system load is now represented by *OC* and scaling the graph we find it equal to 1,888 kva., which is well within the 2,000 kva. rating of the generators.

A summary of the new conditions shows the following:

(1) The load on the alternator is reduced 2,510—1,888=622 kva.

(2) The load in kilowatts is reduced by 1,728—1,700=28 kw.

(3) The reactive kilovolt-amperes are reduced by 1,820—821=999 kva.

(4) The power factor is increased from 68.8 to 90 per cent lagging.

The change thus eliminated the necessity of an additional alternator with its prime mover, extra switching equipment, cables and additional floor space, and thus decreased the cost of operation, and improved voltage regulation and operation of each individual induction motor.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, July, 1925

Why Wait for Belt Trouble to Happen?

BELT trouble on important drives, or any other interruptions to the operation of equipment, always seem to happen when the shop is busiest. It is, however, only natural that the belt should give way when it is called upon to perform its hardest service; it would hardly be expected to fail under light operation or when the shop is shut down.

One operating engineer solved this problem by deciding that instead of waiting until belts stop work because they are dirty, dry, or need tightening, which is more his fault than the belt's, he would, at least once a year, take them down when work was slack or the shop closed and clean them thoroughly, re-oil them and put them back into service with a newly cemented joint. Since this policy of annually going over all belts on important drives has been in practice, no group drive belt has failed in service. It takes time to do a good repair job, and time is mighty scarce when the men on a group of machines are idle because of a breakdown.

The policy of avoiding difficulties instead of overcoming them, seldom, if ever, fails to pay big dividends.

A Load Survey That Was Worth $10,000 a Year

NOT SO very long ago a load survey was undertaken in a large industrial plant. One of the conditions brought to light was quite startling and resulted in a saving of $10,000 a year.

This plant was somewhat like Topsy—"It just grew." In its earlier days, direct-current power was secured by the use of steam-driven generators. When the demand for power became too great for these machines, it was decided to get the additional power from the local central station. Accordingly, a 25-cycle motor-generator set was installed to take care of this requirement. Five years later, due to plant extensions, a large amount of direct-current power was required at the other end of the plant, which is about half a mile away. The cheapest way out was to put in another motor-generator set at this location.

During this five-year period, however, the local utility had decided to curtail their 25-cycle service and push their 60-cycle supply; consequently, a 60-cycle, motor-generator set was installed at the new location.

The load survey that was undertaken several years after the installation of the second motor-generator set brought to light the fact that this consumer was paying a maximum demand charge for his 25-cycle power and another maximum demand charge on his 60-cycle power. This was because there were two separate and distinct services for this plant. The load survey also showed that the maximum demand on the 25-cycle power did not occur at the same time as the maximum demand on the 60-cycle power. It was estimated that there was sufficient diversity between these two demands to warrant replacing the 25-cycle motor with a 60-cycle motor on one motor-generator set and obtaining all of the power from the 60-cycle supply. This was done.

When the monthly bill came in from the power company, it was found that the demand charge on the new 60-cycle service was scarcely larger than before, which meant a saving of practically all of the demand charge formerly made on the 25-cycle power. Of course, the energy charge billed against the company was equal to the sum of the old 25-cycle and the old 60-cycle energy charges.

The saving in this case amounted to $10,000 a year. This investigation of diversity factor was decidedly worth while. On page 310 of this issue, Mr. Stafford gives the elements of a load survey and the methods of making one. If you are interested in cutting power costs in your plant, a perusal of this article will be well worth the time spent.

Make Conditions Justify the Use of Special Equipment

THE use of equipment which is specially designed and built is oftentimes justified by the service conditions that must be met. Nevertheless, this is a question that should be considered very carefully before a decision is made to use other than standard equipment. There are several reasons for this.

In the first place the cost of special equipment is necessarily high, as a good deal of engineering and designing work may be needed and the cost of this must be, at least in part, charged against a comparatively small number of units instead of spread over a large number of units in quantity production, as in the case of standard apparatus. In addition, much of the work may, in the absence of the proper jigs and fixtures, have to be done by hand, which means considerably reduced output; more supervision is required, and there is likely to be greater spoilage and wasting of material.

Furthermore, although the equipment may have been designed with the utmost care there is always the chance that the searching test of service may reveal hidden defects or weaknesses that would probably not be present in standard equipment, whose design has been perfected through the experience gained in watching the equipment under service conditions.

The possible difficulty and expense of getting repairs made and obtaining spare parts is another matter that

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should be considered in connection with the use of equipment that is not standard.

Special equipment has its place, but as a general proposition that place is not in any application where standard equipment can be used.

How Many Tons Do You Handle per Ton of Output?

MARK TWAIN is credited with the remark, "Many people talk about the weather but they don't do anything about it." The same could probably be said of the material-handling problem in many industrial plants. In those plants where the cost of handling material is lumped under "indirect labor costs," this item of expense is considered a nuisance but, when grouped this way comparatively little can be done about it, as usually many other items of expense are included.

Material-handling problems will be but little understood until it is generally realized how extensive they are in industrial processes and also exactly what they cost. Some few years ago the chief engineer of a large midwestern foundry investigated and found that to produce one ton of miscellaneous castings of small size, averaging a few pounds each, required that 168 tons of pig, scrap, flasks, debris, castings and other materials must be handled. Startling as this figure may seem his foundry was very well organized, and investigation showed that many other plants were handling almost twice as much material to get out the same amount of work. This was due to an excessive amount of unnecessary rehandling.

The first step in any work of this sort is to find out exactly how many handlings are made and how much they cost, together with exactly how they are done. The next analysis is to determine how many of these handlings are unnecessary or can be combined with others. After that, it is merely a question of the most effective equipment for the work. These are steps which may be taken in practically any plant and will pay big dividends on the time spent in the investigation. A careful investigation may show you how to do something much more effective than merely talking about your material-handling problems.

Overvoltage on Lamps Means Short Life

A RECENT incident in a large plant brings to mind a subject which ought to be well known, but is not always given the attention that it deserves.

In one department of the plant mentioned, considerable concern was felt because of the change in the life of the incandescent lamps that were being used. Careful investigation was made to see if these lamps were being subjected to unusual vibration or other abuse. It was found that 125 volts alternating current was being supplied to the lamps in question and that these lamps were rated at 115 volts. Further investigation disclosed that 120-volt lamps had been requisitioned, but that the purchasing department had taken it upon themselves to change this to 115 volts, simply because there were no 120-volt lamps in stock at the supply house at the time the lamps were ordered.

The evil effect of operating lamps on overvoltage ought to be well known. In this case, there was an overvoltage of 8.7 per cent which brought the average life per lamp down to 30 per cent of normal. Ordinarily, 120-volt lamps were used on this supply, but even in this case the lamps are operating at 4.16 per cent overvoltage, which gives an average lamp life of about 56 per cent of normal.

The average life of a standard Mazda multiple lamp is said to be 1,000 hr. When using 115-volt lamps, the plant mentioned was getting an average lamp life of only 300 hr. or 25 nights' use of the lamps, whereas by using 125-volt lamps or reducing the lighting voltage to 115 volts they could have expected 1,000 hr. or about three months' life from their lamps.

This incident should point out the value of making a survey of the voltage delivered at the lamp sockets in all parts of your plant and seeing that the proper lamps are used. This survey should be repeated at regular intervals, for load changes or other conditions may affect the voltage.

Money saved on lamp renewals is just as good as money saved in any other way, and it doesn't cost much to find out how much you can save.

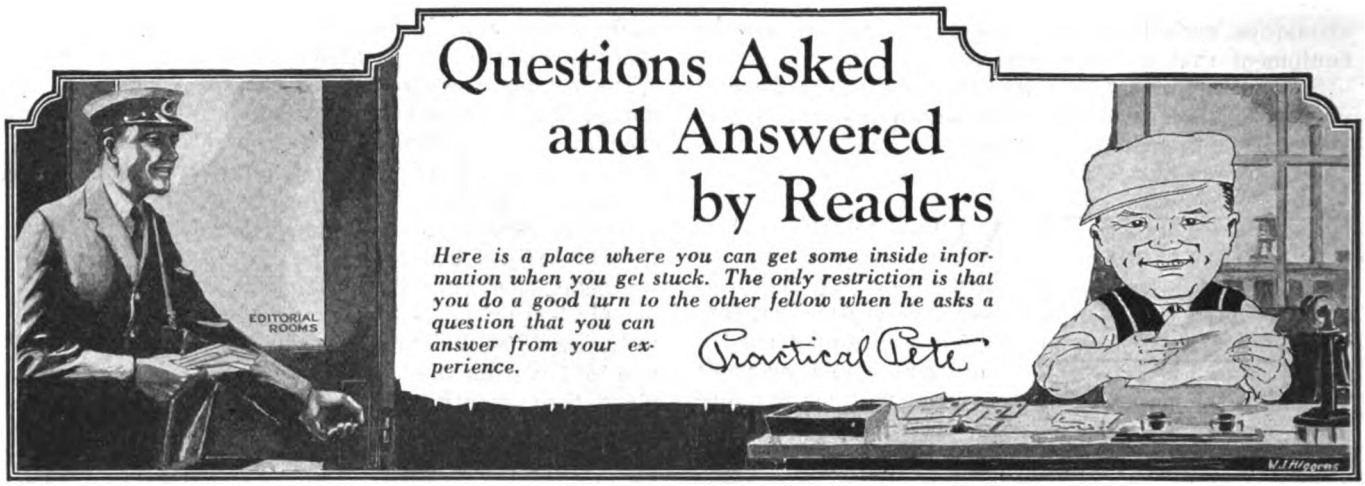
A Study of Your Repair Work May Save You Money

ONE of the problems confronting every medium-sized or large industrial plant is to determine how far the maintenance department should go in doing its repair work and what work is to be sent out to be done. Most industrial men have learned by experience and careful comparison of costs that it usually pays to keep on hand a small stock of parts purchased from the manufacturer, such as bearings and other similar parts, which may be expected to wear out more or less frequently.

The question of whether to rewind motors and make extensive repairs to such devices as commutators is often open to discussion. Usually, the decision depends upon the quantity of work to be done, the outside agencies available and whether any of it is of an emergency nature. One plant with enough winding work to keep a man busy was not satisfied that it could do this work to the best advantage, and made a further analysis of its repair jobs. Here, as in most cases, the decision to do this work in the plant had been made because it was felt best to have a repairman on hand for emergency work on special motors, such as those direct-connected to some machines for which no spare motors were available. An analysis of repair jobs showed that these emergency cases occurred only a few times a year and that they practically always meant overtime work for the winder.

Arrangements were made with a local repair shop to rush these special motors as emergency jobs and put as many men on the job as feasible. Ordinary repairs on motors for which spares are available are handled in the plant repair shop, according to the regular routine, which delivers the motor within a fixed period. This relieves the maintenance department of carrying considerable repair stock and also releases some floor space which is badly needed. Perhaps, it would pay other plants to make a similar analysis of equipment failures, to determine how the repair work can best be handled.

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Who Can Answer These?

Bull Ring for Gas Pump—Can some reader give me any suggestions on how to make a bull ring for the piston of a gas pump having a cylinder diameter of 36.25 in.? In making the ring, what is the allowance in diameter to provide the necessary "spring" to hold the ring tight against the cylinder wall? Also, what is the best type of joint to make in the ring?
Paulding, Ohio. J. G.

* * * *

Use of Armored, Lead-Sheath Conductor Underground—Will some of the readers of INDUSTRIAL ENGINEER please give me their experience with the use of 2,500-volt, lead-encased, steel-wound wire such as is put out by some of the large manufacturers and intended to be used underground, and not protected by conduit?
San Diego, Calif. W. P. B.

* * * *

Method of Cleaning Motor Winding—What is the best method of cleaning motors that are oil-soaked and dirty? Can they be washed in gasoline and baked out in a bake oven to any advantage? What is the best method of handling the gasoline? Should the armatures be dipped in a trough containing gasoline, or should they be wiped with a gasoline-soaked rag? I would greatly appreciate hearing of any other methods used by readers for cleaning oil-soaked windings, as well as the results obtained by using gasoline for cleaning.
Chicago, Ill. R. W. A.

* * * *

Mounting Motors on Ceiling—In order to get more free floor space we are planning on mounting the motors on the ceiling, above the machines and lineshafts which they drive. I should like to have the experiences of other readers on the following points: (1) The best method of attaching motors to concrete ceilings. (2) What is the best and simplest method of raising and holding motors up until they can be attached? (3) Is there likely to be any more trouble with motors so mounted, than when they are placed on the floor?
St. Louis, Mo. E. H. G.

* * * *

Method of Removing Cores from Fan Motors—Will some reader tell me the best method and equipment to use for removing the cores from 10-in., 12-in., and 16-in. Westinghouse fan motors? I find it necessary to remove these cores from the drawn steel housing that encloses the motor so as to be able to make repairs on the connecting wires, which usually burn off very close to the housing. This connection cannot be made on the outside. These field cores fit so closely that it is almost impossible to remove them without injury to the windings with all the methods that I have tried so far.
Madisonville, Ky. E. F. L.

What Causes These Brushes to Chatter?—I have a three-phase, 440-volt,70 hp., slip-ring motor which is giving trouble from chattering of the brushes. Everything that I know of has been tried to prevent this, but without success. The brushes will stop chattering immediately after the slip rings are sanded slightly while the machine is in operation. But after several hours they begin to chatter again. I shall appreciate it very much if some of the readers of INDUSTRIAL ENGINEER will tell me how I can overcome this trouble.
Los Angeles, Calif. F. P. B.

* * * *

Emergency Excitation for Generators—For exciting our generators we have one motor-driven exciter which is normally in use. After the station has been completely shut down, we have one steam-turbine-driven exciter which is used for starting. Suppose that when we attempt to start up, the steam-driven exciter should break down. How could we excite our field? Could it be done by using several automobile storage batteries in series? For exciting our generator at no load, we require 60 amp. at 65 volts and it would be necessary for this supply to be on for approximately 10 min. Would it be practicable to use eleven 6-volt storage batteries in series for supplying this excitation? If so, what capacity should the storage batteries have? I shall appreciate any information that readers can give me on this problem.
Medicine Hat, Alta., Can. E. R. S.

Answers Received To Questions Asked

Rewinding 110-Volt Generator for 6 Volts—I have a 110-volt, 0.25-kw., 2,000-r.p.m., shunt-wound generator and should like to know if it can be reconnected or rewound to give six or eight volts, for charging storage batteries. If so, will some reader please give me some information on the size of wire to use, number of turns and so on?
Allentown, Pa. A. H. S.

With reference to the question asked by A. H. S. in the May issue, he does not state the size of wire in the armature or field or give any data regarding the commutator segments. The present output of the generator is 0.25 kw. at 110 volts, which would be approximately 186 watts, with a current of 1.7 amp. To change this over so that 6- to 8-volt storage batteries could be charged, would necessitate rewinding the armature and fields for 12 volts. Assuming that the output would be the same as on 110 volts, the wire in the armature would have to carry approximately 15.5 amp. It is doubtful whether the commutator segments would handle the current without giving trouble. Also, the brushes and brush holders would have to be remodeled.

A. H. S. can determine the present size of wire and count the number of turns in the field and the number of turns per armature slot. In rewinding the armature and field coils, decrease the number of turns approximately in the ratio to the decrease in voltage; that is, in the ratio of 110 to 12. Also, increase in the size of wire so as to enable it to carry 15.5 amp.

This is a rough method, but with the data at hand this is all the information I can give. I might state, however, that I do not think it practicable to change this machine over for the low operating voltage.
Chief Electrician, Shevlin-Hixon Co., Bend, Ore. WILLIAM B. CONE.

* * * *

Operating Motors in Parallel on Bridge Motion of Crane—Two series motors are used to drive the bridge motion of one of our cranes. Each motor drives one set of track wheels, so that the two motors are practically operating in parallel. They are controlled by two contactor panels operated from one master switch. With this combination the armature burnouts were so frequent that it was decided to connect the armatures of the two motors in series and the fields in parallel. As we still had burnouts it was decided to connect the armatures and fields all in series. This has eliminated a great deal of the trouble, but it reduces the speed of the bridge.

I would like to know what is the cause of the trouble that I have been experiencing. Can some reader suggest a method of connection that will eliminate the trouble from burnouts and at the same time give normal speed on the motors?
Indiana Harbor, Ind. A. R. D.

With reference to A. R. D.'s question in the May issue, the two motors on the crane bridge might to great advantage be connected with the armature of each in series with the field of the other. This arrangement would bring the motor speed up to normal and also would make an equal division of the load between the two motors. It is understood that one controller is now used for the two motors. If this is not the case, it is believed that such an arrangement should be made, as then each motor would be working under the same conditions at all times. The control equipment and wiring on the bridge would be reduced almost 50 per

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cent by using only one controller. Likewise, the expense for spare parts for the controller would be reduced in the same proportion, while the probable time lost by the crane due to electrical trouble with the bridge equipment would be reduced by more than 50 per cent. D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

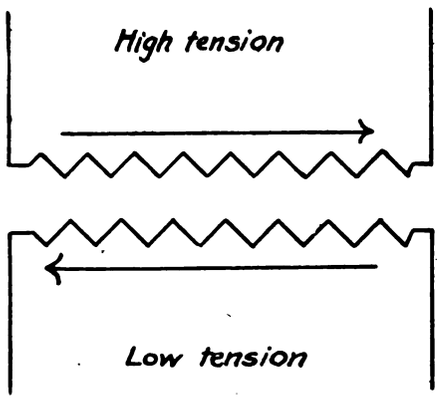
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In answer to A. R. D. in the May issue, I would say that his second method of connecting the two motors in parallel is correct. I would suggest that he check up on the control, and check the fields for roasted coils, partial shorts, and polarity. Then if the motors appear to be all right, make ammeter tests on both motors to see whether or not the motors are overloaded. Also, make sure that the crane is in good condition mechanically.

We recently had a series motor on the trolley of one of our large cranes which gave us considerable trouble. The armature drew an abnormally large amount of current, sparked badly at the brushes, and finally burned out the armature. On taking the motor apart, we found that it had been running for some time with some of the poles having incorrect polarity.
Detroit, Mich. A. J. CONWAY.

* * * *

Polarity of Transformer—After reading the article on "Checking and Testing Transformer Connections" on page 560 of the December, 1924, issue of INDUSTRIAL ENGINEER, I am somewhat confused as to the relationship between the primary and secondary voltages for transformers of different polarities. Assume a transformer having primary and secondary voltages in the winding as shown by the arrows in the diagram. Can some reader tell me whether this transformer has additive or subtractive polarity, and why?
Chicago, Ill. G. A. V.



In reply to the first part of the question asked by G. A. V. in a recent issue, the whole trouble and misunderstanding are due to the fact that not enough attention has been given to the terminal markings of the diagram and too much attention and weight have been given to the arrows without understanding what they mean. In fact, it might be better to eliminate the arrows entirely as they seem to be the cause of all the misunderstanding regarding the polarity.

Disregard the arrows for the moment and you will see that Figs. 1 and 2 on page 561 of INDUSTRIAL ENGINEER, and which are shown in the accompanying diagrams, are correctly marked for subtractive polarity and additive polarity, respectively, in accordance with the definition of polarity as given in Electric Power Club rule 9077 and in accordance with rules 5407, 5411 and 5412. The latter three rules cover the marking of the leads.

Rule 5412 states that the numbering of leads shall be so applied that when H_1 and X_1 are connected together, and

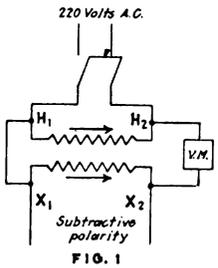


FIG. 1

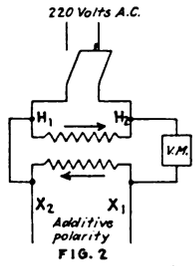


FIG. 2

Methods of testing transformers for polarity.

In Fig. 1 two adjacent high-and low-tension terminals, H_1 and X_1, are connected together and a voltmeter is connected to the other two adjacent terminals, H_2 and X_2. The 220-volt, alternating-current power is applied to the high-tension winding as shown. If the voltage measured on the voltmeter is less than the voltage applied to the high-tension winding the transformer has subtractive polarity, as shown in Fig. 1. If the voltage reading is greater than the supply voltage, the transformer has additive polarity, as shown in Fig. 2.

voltage applied to the transformer, the voltage between the highest numbered H lead and the highest numbered X lead shall be less than the voltage of the full high-voltage winding. From this it will be seen that the voltmeter in Fig. 1 must read less than the voltage of the highest voltage winding. By the definition given in rule 9077, this makes the transformer have subtractive polarity. For the same reason, the voltmeter in Fig. 2 must read more than the voltage in the high-voltage winding, making its polarity additive. These requirements for additive and substractive polarity are not affected by any arbitrary use of undefined arrows.

If arrows are used at all, they should, to be consistent, have the same meaning in both primary and secondary windings. In other words, they should both point either from or toward the highest numbered lead in both cases and this condition will be fulfilled if the arrows are assumed to represent induced voltages in both windings. This will not only prove consistent with the rules already mentioned for the numbering of the leads, but will also make the voltages in the case of interconnection between the two windings, add or subtract according to the arrows.

The arrows cannot represent induced voltage in the secondary and impressed voltage in the primary with the lead markings as shown.

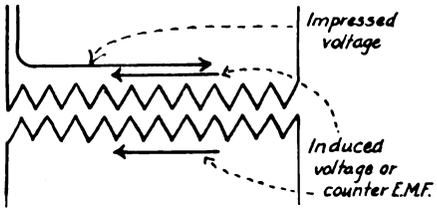
Referring now to the latter part of the question asked by G. A. V., it is impossible to answer this as it stands, although the arrows are said to represent primary and secondary voltages. The question does not state whether these arrows represent induced or impressed voltages, nor does the diagram give any terminal markings. The diagram therefore, can be said to represent additive or subtractive polarity, depending upon what primary or secondary voltages the arrows are supposed to represent, or what terminal markings are given to the leads.

If arrows are to be used in the diagram, it is better to have them represent induced voltages in both the primary and secondary windings. This produces perfectly consistent diagrams in that both the direction of the arrows and the markings of the leads will agree. However, as I have stated before, it might be simpler to eliminate the arrows altogether and use just the terminal markings. S. N. CLARKSON.
Executive Secretary,
The Electric Power Club,
Cleveland, Ohio.

* * * *

In reply to the question asked by G. A. V. in a recent issue the transformer has subtractive polarity if the high-tension voltage as shown in the diagram is the impressed or line voltage, and if the low-tension voltage is the induced voltage. On the other hand, if both arrows are taken as indicating induced voltages, then the polarity of the transformer is additive.

To make this clear I am showing the relation between the impressed or line voltage and the induced voltage, in the accompanying diagram. We know that when voltage is impressed on any coil, there is an induced or counter-voltage in opposition to the impressed voltage.



Relation between impressed and induced voltages.

The voltage impressed on the primary of the transformer causes a current to flow which generates a flux. This flux acts on both the primary and secondary windings and induces a voltage that is opposed to the impressed voltage.

This induced or counter-voltage is the same in both windings, since both windings enclose the same magnetic field. We believe that a good bit of the confusion regarding the question of polarity is due to the terms, *impressed* and *induced* voltage. When these are separated or specified the solution becomes simple. J. B. HODTUM.
Western District Office,
Pittsburgh Transformer Co.,
Chicago, Ill.

* * * *

Answering the question by G. A. V. in a recent issue, the transformer shown in his sketch has subtractive polarity if the arrows are taken as representing the instantaneous direction of current in the primary and secondary windings. Granting that the arrow

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on the primary winding indicates the direction of the impressed current and likewise the direction of the impressed voltage, then the arrow on the secondary winding would show the direction of the induced current and induced voltage. In the case shown in G. A. V.'s diagram, these arrows are opposed to each other; consequently, if the left-hand, high-tension and low-tension leads be connected together and a voltmeter connected across the right-hand, low-tension and high-tension leads, and at the same time the high-tension winding be excited, the voltmeter will read the difference in the two voltages and since this would be less than the value of the impressed primary voltage, the transformer would have subtractive polarity.

ERNEST DICKINSON.
Kimberley, B. C., Can.

* * * *

In the question asked by G. A. V. is shown a diagram indicating a transformer having additive polarity. The usual method for testing this is very clearly indicated in Mr. Staubitz's excellent article in the December issue of INDUSTRIAL ENGINEER, where he explains the diagrams on page 561. Additional explanation going further into the details of what actually happens in the transformer winding may also be helpful.

In an alternating-current circuit, the voltage is zero at one instant, then increases to full value in the positive direction, reverses and falls to zero, increases in the negative direction and then falls to zero again. There are 60 of these complete cycles per second in a 60-cycle circuit. Whenever the voltage increases in one direction or the other, lines of magneto-motive force are caused to increase in the iron of the transformer. These lines of force are not only enclosed by the primary coil, but also by the secondary coil and therefore an induced voltage is produced in the turns of both windings and both will be in the same direction at the same time. Since the voltage is constantly changing in this manner, we will consider the conditions existing in the transformers at one particular instant.

Assume that at a certain instant, voltage is impressed in the primary of a transformer. This causes a magnetic flux in the transformer iron as indicated by the dotted-line arrows in the iron of the transformers in the accompanying diagrams, *A*, *B*, *C*, and *D*.

It should be noted that the voltage arrows which represent induced voltages in the windings will all take the same direction because the voltages in both the primary and secondary windings are induced by the same flux. This holds good whether the secondary is wound counter-clockwise as in transformers *A* and *B*, or clockwise as in transformers *C* and *D*. An inspection of the method of winding these transformers will indicate that this does not affect the polarity. The polarity is determined entirely by the way in which the transformer leads are brought out of the transformer tanks. According to the A. I. E. E. standards "the polarity of a transformer is subtractive when H_1 and X_1 are adjacent, and additive when H_1 is located diagonally across from X_1."

Furthermore, the rules state that "the H_1 lead should be brought out at the right-hand side of the case when facing the high-voltage side of the case." Transformers *A*, *B*, *C* and *D* all have the H_1 lead so located. All of these transformers have the primary windings wound counter-clockwise. Transformer *A* has its secondary winding also wound counter-clockwise and by making the voltmeter test as described in Mr. Staubitz's article (that is, connecting two adjacent leads, say H_1 and X_1, and connecting a voltmeter across H_2 and X_2), it will be seen that the polarity of this transformer is subtractive. Transformer *B*, however, is wound exactly the same way, but the secondary leads are crossed before bringing them out of the tank, so that connecting the same two adjacent leads we get H_1 and X_2 connected together and the voltmeter test shows this transformer to have additive polarity. In order to make this transformer operate in parallel with transformer *A*, it is therefore necessary to cross the leads again, when connecting it in parallel with transformer *A*. Transformer *C*, although it has the secondary wound exactly opposite to transformer *A*, is made to have subtractive polarity the same as transformer *A*, by crossing the leads before bringing them out of the tank. Transformer *D* has its secondary wound exactly the same as transformer *C*, but because the leads were not crossed before bringing them out of the tank, it will be necessary to reverse them afterwards in order to have this transformer operate in parallel with the other three transformers. However, since the polarity of a transformer is determined entirely by the way the leads are brought out, its polarity is opposite to that of *C*.

If the leads on any one of the four transformers shown were arranged so that its X_1 lead was connected to the same bus as the X_2 leads of the other transformers, and its X_2 lead connected to the same bus as the X_1 leads of the other transformers, there would be a surge of current through the secondary windings which would cause fuses to blow or circuit breakers to open.

ROGER F. EMERSON.
Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

* * * *

In reply to the question asked by G. A. V. in a recent issue, I would say that the polarity of the transformer shown in the diagram is additive. I would refer you to the definition of polarity given by the American Institute of Electrical Engineers, which is as follows:

"If the primary and secondary windings have a relation such that the two leads nearest each other can be joined together and the voltage across the two windings is greater than the voltage of the high-tension winding, then the polarity is additive or increasing. If less, the polarity is subtractive or decreasing."

THOS. M. HUNTER.
American Transformer Co.,
Newark, N. J.

* * * *

In reply to the question asked by G. A. V. in a recent issue, I would say that a transformer having the characteristics as outlined in his diagram has additive polarity. A transformer having subtractive polarity has its secondary so connected that the induced current opposes or bucks the current of the primary. In other words, the currents act against each other in the same way that two streams of water would should they be turned against each other. When the transformer has additive polarity the two currents work together.

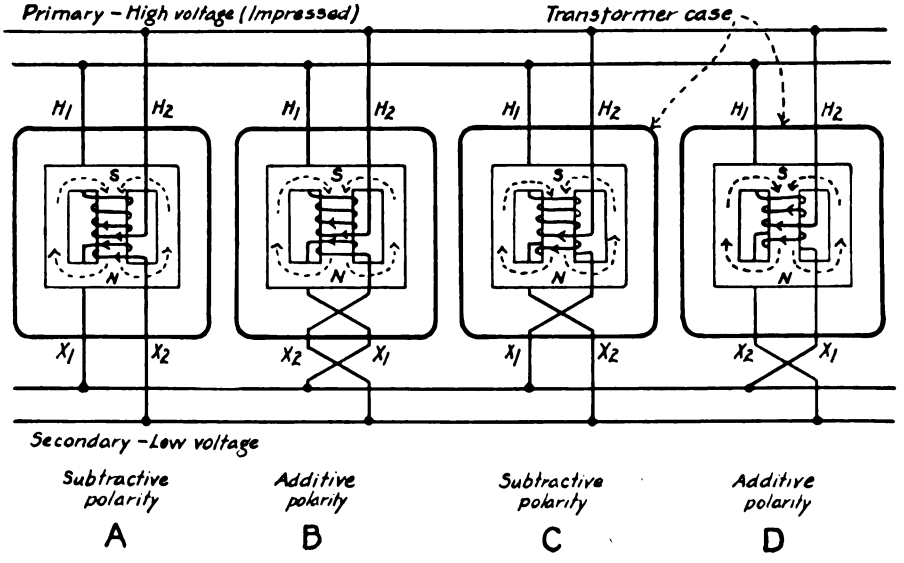
Riverside, Cal. PHIL D. COMER.

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With reference to the question asked by G. A. V. I think that the following discussion will solve his problem.

In Fig. 1 of the accompanying dia-

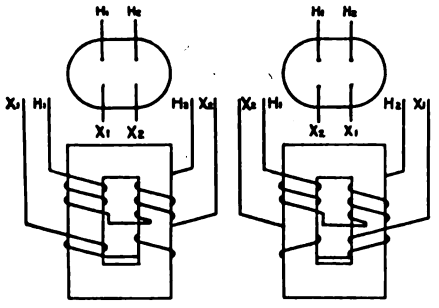
These transformers are correctly connected for parallel operation, although they are of different polarities caused either by the primary and secondary windings being wound in opposite directions or by crossing the secondary leads within the transformer case.



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gram, the high-voltage and low-voltage sides of the transformer are wound in the same direction, assuming that H_1 and X_1 are the starting points.

In order to prevent confusion it is advisable to neglect current and think only in terms of induced voltages. Since the same flux induces both the high and low induced voltages, they must be in the same direction in each turn. However, whether they will appear in the same or opposite directions as viewed from the terminals depends upon the relative direction of the winding. Thus, in Fig. 1, voltages H_1H_2 and X_1X_2 are in the same direction and in Fig. 2 voltages H_1H_2 and X_2X_1 are in opposite directions. If we take the order of lettering to indicate the direction of the induced voltage, then in Fig. 1 voltages H_1H_2 and X_1X_2 are in the same direction and in Fig. 2 voltages H_1H_2 and X_2X_1 are in opposite directions.



Figs. 1 and 2—Polarity is the relative direction of the induced voltage from H_1 to H_2 as compared with that from X_1 to X_2.

When the induced voltages of the high- and low-voltage sides are in the same direction, as in Fig. 1, the polarity is subtractive and when the induced voltages are in opposite directions, as in Fig. 2, the polarity is additive.

Referring to the tank sketches at the top of Figs. 1 and 2, polarity is the relative direction of induced voltage from H_1 to H_2 as compared with that from X_1 to X_2. When the induced voltages of the high- and low-voltage sides are in the same direction, as shown in Fig. 1, the polarity is subtractive and when the induced voltages are in the opposite directions, as shown in Fig. 2, the polarity is additive.

M. F. MITSCHRICH.

Moloney Electric Co.,
St. Louis, Mo.

* * * *

In reply to the query of G. A. V. in a recent issue, I find the following a very easy way to remember the relative polarity of transformers. My method is to follow the polarity arrows on both the primary and secondary sides right through. If they help each other (add to each other) the transformer is of additive polarity. In other words, in the diagram given by G. A. V., if he will start at the left-hand side of the high-tension winding and follow through the winding in the direction of the arrow and then go down to the adjacent low-tension side at the right and go through this winding, he will find that he will have traveled through both windings in the same direction as the arrows indicated. On the other hand, however, if one of the arrows is opposed to this direction of travel, then the transformer is thought of as being subtractive. This is a very easy way to remember the polarity.

EDWIN W. LINDOP.

Service Department,
General Electric Co.,
Los Angeles, Cal.

* * * *

Using Vacuum Pump as Air Compressor—I have a Wahl vacuum pump, size 4 in. by 2½ in., with ¾-in. inlet and outlet, which I wish to use as an air compressor. The pressure in the air tank need not go over 125 lb. per sq. in. Will someone please tell me. (1) What size motor would be required to drive this pump at 275 r.p.m. (2) Will it be necessary to make provision for cooling this pump artificially, by means of air fins or water, in order to keep the temperature down to a safe limit? (3) How do you figure the cubic inches of air compressed per stroke?

Dallas, Tex. R. E. L.

In the May issue are answers by R. A. Kiefer and E. H. Laabs to a question by R. E. L. on the practicability of using a 4-in. by 2½-in. vacuum pump as an air compressor to work under a pressure of 125 lb. per sq. in. Mr. Kiefer condemns the idea because, he thinks, the cylinder is not strong enough to stand a pressure of 125 lb.

The formula for the required thickness of a cylinder subjected to internal pressure is $t=(P\times d)\div(2\times S)$, in which t is the thickness of cylinder wall in inches, P the pressure per sq. in., d is the bore of the cylinder in inches and S the working strength of the material.

In the case that was under discussion, with P=125 lb., d=4 in., and S (cast-iron)=2,500 lb., the required thickness is $t=(125\times4)\div(2\times2{,}500)=0.1$ in. Surely, the cylinder wall is 0.1 in. in thickness! Because of practical considerations, the thickness of the wall of the cylinder of R. E. L.'s vacuum pump is probably not less than 0.5 in.; so it would seem that strength is not an important consideration.

In figuring the capacity of the compressor, Mr. Laabs evidently assumes 100 per cent volumetric efficiency. A compressor of the size under discussion would probably have a volumetric efficiency of about 75 per cent; so the capacity at 275 r.p.m. would be (assuming a single-acting machine) 3.75 cu. ft. free air per minute.

Single-stage compression to 125 lb. is not considered good practice because it is less efficient than two-stage compression and, worse still, produces a temperature that is destructive to lubricating oil. The adiabatic temperature of air compressed to 125 lb. gage, is above 500 deg. F.; so any system of cooling that R. E. L. succeeds in applying to this compressor will probably not prevent some trouble in maintaining lubrication.

The reason for reducing the size of outlet from ¾ in. to a ⅜-in. or ¼-in. check-valve, as recommended by Mr. Laabs, is not clear. The only effect that this reduction would have would be a slight restriction to the flow of the air—and perhaps lower cost of valves and fittings.

Los Angeles, Cal. C. O. SANDSTROM.

Trouble With Rewound Automobile Generators—I have been rewinding some automobile generators, but in spite of the fact that I always check up the old winding and make the new one as nearly like it as possible I sometimes have trouble in getting the proper amperage out of the generator. The voltage will be up to normal, six volts, but the charging rate is too low. I wish some reader who has had experience in such work would give me some suggestions as to where the trouble may be.

Bathurst, N. B., Can. H. J. M.

In answer to H. J. M.'s question in the March issue, I believe that his trouble is due to improper connection of the leads to the commutator. From his description it would appear that the leads have been dropped back too far, that is, dropped in the direction of rotation. All automobile generators are driven in the same direction as the engine turns and the third brush is adjusted in the direction of rotation to increase the amperage or output. If the leads come to the commutator one bar ahead of the place where they were in the original winding, the output may be cut down. On the other hand, if they are put in the commutator one bar behind the original position, the output will be increased and the third brush must be moved opposite to the direction of rotation to cut down the output. Changing the third brush a fraction of an inch will sometimes change the charging rate 8 or 10 amp.

It is also quite possible that H. J. M.'s trouble is due to weak field coils as these will keep the charging rate down, especially if they are old and oil-soaked.

Albany, Ga. B. BELCHER.

* * * *

Thickness of Mica Required for Slot Insulation—Will some reader please tell me what thickness of mica should be used to replace one layer of 0.007- or 0.010-in. varnished cambric and one layer of 0.007- or 0.010-in. fishpaper for slot insulation?

St. Louis, Mo. L. C. R.

In answer to L. C. R. in the March issue, the thickness of any slot replacement insulation depends not only upon the dielectric strength of the insulation but upon the thickness of the original and of the replacement insulation. Naturally, less mica insulation will be required for a given dielectric equivalent than when varnished cambric and fishpaper are used, but if no more than the dielectric equivalent is used the coil will be loose in the slot and subject to vibration with ultimate breakdown.

Authorities differ considerably on the dielectric strength of materials. For general reference, however, the following values may be used:

Varnished cambric, 1,000 volts per mil. Fishpaper, 200 volts per mil.

The dielectric strength of mica varies from 2,000 volts for 2- and 3-mil amber mica to 4,000 volts for ruby mica.

West Allis, Wis. EDWARD JAMES.

* * * *

In answer to L. C. R.'s question in the March issue, he does not state what type of motor, that is, d. c. or a. c., or whether open or partly-closed slots are referred to. In the case of open slots, on either d. c. or a. c. machines, the following information may be of help to him.

One thickness of 0.015-in. or 0.020-

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in. molding mica (Westinghouse No. 251 mica plate) can be cut the right width to suit the depth of the slot and a trough cut in a piece of hard wood which is the same width and depth as the slot and slightly longer than the core. Then cut a piece of wood the correct size to act as the male part of the mold, heat the mica plate and form it in the above mold, keeping it under pressure until cold.

Or No. 240 cambric and mica can be used. This comes in sheets 25 in. by 52 in. and is 0.013 in. thick. It can be cut and applied like fishpaper, etc.

There is a grade of flexible mica, No. 237, that comes in sheets 24 in. by 36 in. and 0.005 in., 0.010 in., 0.015 in., 0.020 in. and $\frac{1}{32}$ in. thick. This material can be cut and applied cold like varnished cambric for coil cells, but for slot insulation a backing of fishpaper is required. I would suggest the following: 0.010-in. flexible mica between two pieces of 0.004-in. fishpaper. This will give mechanical protection to both sides of the mica cell.

For slot insulation to be applied to the coil, I would suggest one and one-half turns of 0.010-in., No. 237 flexible mica or one and one-half turns of 0.012-in. No. 232 mica and fishpaper.

Wilkinsburg, Pa. A. C. ROE.

* * * *

In answer to L. C. R. in the March issue, mica does not have sufficient mechanical strength to be used alone for slot insulation. It can, however, be used with a fishpaper backing. Fishpaper and mica glued together so as to form one sheet may be purchased. The standard thickness of this material is 0.012 in.

If you cannot obtain fishpaper and mica in this form, use fishpaper of the same thickness that was originally used in the slot and mica which is equal in thickness to the varnished cambric.

Boulder, Colo. RALPH MCKINNEY.

* * * *

In answer to L. C. R.'s question in the March issue, I would advise using all the available space that he will have in the slot after the removal of varnished cambric and fishpaper, for the mica. The additional thickness will enable the coils to stand the heat better and will also give a larger factor of safety in the winding.

Fishpaper tests at about 200 volts per mil thickness. A 7-mil paper would, or should, when dry, stand about 1,200 volts. This paper ordinarily has about 8 per cent moisture. If the moisture content is very high the paper is a very poor insulator.

Varnished cambric should stand from 500 to 1,000 volts per mil thickness, up to about 20 mils thickness. A 10-mil thickness of varnished cambric would, of course, stand a test of approximately 5,000 volts.

Amber mica tests about 2,000 volts per mil, and white or clear mica tests about 3,000 to 4,000 volts per mil thickness. Clear mica in its original state is not flexible enough to use for coil insulation. It can be cut to fit the slots for the side of the coil insulation, and a strip cut for the bottom, the width of the slot. Mica cloth or some similar flexible material should be used to insulate the coils. Slot insulation can also be formed of molding mica. As slot insulation these materials could not be rated at such high voltage as the tests indicate. From L. C. R.'s question I judge that the voltage is 220 or 440. Also the coils probably have some insulation, at least cotton tape which, when it is properly impregnated, will test about 1,000 volts per mil.

The table given below for slot insulation thickness is found in Prof. Stills' book "Principles of Electrical Design," published by McGraw-Hill Book Co. This table is for one side of slot only. These figures also apply to the thickness of the insulation to use between upper and lower coils in slots.

	Voltage	Insulation, Inches
D. c. machines up to	250	0.035
	500	0.045
	1,000	0.06
	1,500	0.075
A. c. machines up to	1,500	0.075
	2,000	0.080
	4,000	0.120
	8,000	0.190
	12,000	0.270

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Connecting Commutator Leads of G. E. 25-Cycle Desk Fan Armatures—Will some reader please tell me the general layout of the coils and how the top and bottom leads are connected to the commutators of G. E., Type AOU, Form V2, 25-cycle desk fan armatures? I have rewound two different armatures without much success, for when the fan is connected across the line the armature rotates only very slowly, with the fan removed.

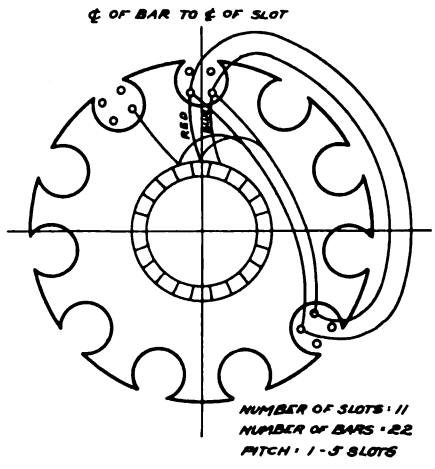
Phoenix, Ariz. F. R. S.

In the April issue F. R. S. asks for information on connecting a G. E. desk fan, Type AOU, form V2.

The accompanying connection diagram shows the coil throw and commutator connections. I trust this will give F. R. S. the information he desires.

Data Bureau, E. A. OTTO.
Pittsfield Division, General Electric Co.,
Pittsfield, Mass.

This diagram shows the coil throw and commutator connections of G. E., Type AOU, form V2 desk fan armatures.



How to Use Megger for Testing Insulation of Motors—I wish some reader would give me a few suggestions on the proper method of using a megger for testing the insulation resistance of motors. I should also like to know what is considered a satisfactory reading when testing 110/550 volt, a. c. and d. c. motors ranging from 5 hp. to 50 hp.

Latrobe, Pa. J. K. W.

Answering J. K. W. in the March issue, the manufacturer of the megger can give the best and most reliable information, but for general purposes, the following covers the necessary points to consider: In using a megger, connect the terminal marked "earth" to the frame of the machine to be tested; the other terminal should be connected to the line or coils of which the insulation resistance is to be tested. Turn the crank as rapidly as possible, and take the reading on the scale while the megger is running at its highest speed, which will be just before the clutch slips out.

The following formula can be used to check the results of the test and determine the condition of the insulation: Insulation resistance in megohms=machine voltage÷(rated kva.+1,000).

For example, a 2,200-volt motor rated at 1,500 kva. should have an insulation resistance of 880,000 ohms.

The formula given above applies only to dry apparatus. Such high values are not attainable in oil immersed apparatus. It must be borne in mind that these values apply only at operating temperatures. A motor measuring two megohms when cold will in general only show a fraction of a megohm at operating temperatures.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In reply to J. K. W. in the March issue, I would suggest that he, and any other readers who wish such information, write to James G. Biddle, 1211 Arch St., Philadelphia, Pa., whose advertisement appears on page 49 of the March issue of INDUSTRIAL ENGINEER, and ask for pocket manual 1060E which will give more information than it is possible to incorporate in a reasonable answer to this question. This booklet gives the A. I. E. E. and the Underwriters' regulations. The manufacturer of the motors can also furnish prints showing requirements for megger readings under various conditions.

For the benefit of those who are not interested in the publication mentioned above, a reading under one megohm is considered unsatisfactory. Readings on cold machines of the rating specified in the question may vary from 1 to 5 megohms. Temperature greatly affects the readings, the resistance decreasing with increase of temperature. When testing the machine should be "dead." Connect one line to ground from the proper side of the megger, as marked, and the other line to the conductor or portion to be tested. The crank should be turned not in excess of 120 r.p.m. About 500 volts will be generated at this speed; if the crank is turned at a higher rate of speed the insulation may be punctured. A direct reading of insulation resistance is shown on scale.

Tests can be made between phases

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in the same manner by connecting lines from megger to phase leads. An important point to note in testing machines to ground is that lines from the machine may be the cause of poor readings. If doubt should arise in this matter the lines can be disconnected, the machines tested as units and the lines tested separately.

As stated before, readers will find it highly advisable to procure pocket manual 1060E or a similar manual from the maker of their instrument.

West Allis, Wis. EDWARD JAMES.

* * * *

In reply to J. K. W. in the March issue, the insulation resistance of low-voltage, up to 600 volts, a. c. or d. c. motors, should be as much as 1 to 5 megohms on a cold machine. When the machine warms up the insulation resistance will be lowered. When testing 110- or 220-volt machines, it is best not to turn the crank of the megger more than 120 r.p.m.

When cold, the resistance of high-voltage machines is about 90 to 100 megohms. One megohm is considered the limit of safe insulation resistance for low-voltage machines.

The values given above apply to motors up to 100-hp. rating. I hope that this information will be of some assistance to J. K. W.

Chief Electrician,
E. I. du Pont Co.,
Newark, N. J. H. CHARLTON.

* * * *

In answer to J. K. W. in the March issue, the megger should not be of too high range; a scale reading from 0 to 200 megohms is ample. With this scale readings as low as 10,000 ohms may be obtained. The megger should be placed on a level, solid support. The line wires should be connected to the winding to be tested and the ground or earth wire to the frame of the machine. These wires should be firmly fastened and not held in the hand. If the line wire is held in the hand, the reading will probably be the insulation resistance of the body to ground. If necessary, the wires may be supported by dry strings so that they will not touch each other, or any part of the machine except that to which they are attached.

When using the megger, do not try to bring up the speed too rapidly, or you may damage the instrument. Turn the handle at such a rate that the clutch slips. Continue at this speed until you obtain a constant reading. This will require only a few seconds for small motors, but may take a minute or more for large generators, due to their capacity. A slight shock may be received if the wire is removed before the generator in the megger has come to rest.

Any reading over one megohm is usually considered satisfactory for motors operating under 600 volts. If the motor is dirty or damp, it should be thoroughly cleaned and dried. Then test it again and keep a record. The motor should be tested at regular intervals and when the test shows a much lower reading than was obtained when the motor was known to be in good condition, it should be overhauled at once.

Boulder, Colo. RALPH MCKINNEY.

Rewinding Armature Increased Speed—I recently rewound the armature of a 100-hp., four-pole, shunt-wound, Northern motor and wish someone would tell me what is the matter with it. This armature had 110 bars and 55 slots and was wave-wound, with one dead coil and one half-idle bar. The coil pitch was 1-and-13 and the commutator pitch 1-and-56. When we rewound it one bar was taken out, which left 109 bars and one dead coil. I am not sure whether the commutator pitch was 1-and-56 or 1-and-55. When the armature was put back in the motor it ran at about 1,600 r.p.m., the commutator got hot and the bands threw solder, although the controller was on only the third point. I examined the field connections and took the voltage drop across each field coil; everything tested out OK. As a further check, a spare armature was put in this motor, and ran perfectly. Any suggestions you can give will be very welcome.

Wisconsin Rapids, Wis. W. B. L.

In answer to W. B. L.'s question in the April issue, I would suggest that he check up the span of his coils and see if he did not drop a slot. The commutator pitch on this armature should be 1-and-56. I know that in winding d. c. armatures if a slot is dropped in placing the coils in the armature, the motor will run up to or above normal speed on the first point of the rheostat. I recall one instance where one slot was dropped by mistake when rewinding the armature of a shunt-wound motor. When the motor was assembled, it ran above the speed given on the nameplate, when the controller was on the second point. The normal speed was 400-1,600 r.p.m., and the motor ran at 1,800 r.p.m on the second point. The field coils were checked for continuity and the pole pieces were removed to see that there was no rust or dirt under them. We finally wrote to the manufacturer asking for data on this machine and from his reply learned that the coils did not span enough slots. The armature was taken out and one side of the coils raised and spread to the next slot and the leads again laid down. After assembling this motor, it ran perfectly, showing clearly the cause of the trouble.

I hope that this experience will be of some benefit to W. B. L. and other readers of INDUSTRIAL ENGINEER.

Albany, Ga. B. BELCHER.

* * * *

In the April issue W. B. L. mentions the trouble which he has had with a 100-hp. armature that was rewound. The fact that one bar was left out would, if anything, tend to help the commutator. He says that there are 55 coils. The nearest correct span of coils would be 1-and-14 instead of 1-and-13. A throw of 1-and-13 comes out 1-13-25-37-49. A throw of 1-and-14 comes out 1-14-27-40-53, which is nearer to 55 than is 49. Possibly an error was made when the armature was stripped. When an armature from a four-pole machine has 109 bars and connects on the half, it could be connected either 1-and-55 or 1-and-56, the only difference being that a throw of 1-and-55 would cause the armature to run in the opposite direction to what it would with a throw of 1-and-56. A Northern motor is very sensitive to a slight shifting of the leads.

If the armature had originally been wound with a throw of 1-and-14 and then changed to 1-and-13, this would naturally cause a difference in the setting of the rocker arm. We once changed the throw of an armature with 61 coils from 1-and-16 to 1-and-15. When the armature was put back in the motor the commutator and the winding got excessively hot after a few minutes' running. The brushholder could not be shifted on this machine; so we had to connect the coils with a span of 1-and-16 again, after which the machine ran cool.

A motor can, of course, be speeded up somewhat, usually about 100 r.p.m., by shifting the rocker arm. W. B. L. does not say how much faster than normal the armature turns and it might be well to check the setting of the brushes as a possible source of the trouble.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

With reference to W. B. L.'s question in the April issue, I believe that if he will carefully check his lead throw, he will find that the leads are not connected to the commutator at the proper place for the brush setting. I would suggest that he check this point up very carefully.

The armature appears to be drawing an excessive current. From this circumstance, it would appear that a mistake may have also been made in the size of wire and number of turns used when rewinding this armature, and I believe it would be worth while to check up on this.

Service Dept.,
Westinghouse Electric & Mfg. Co.,
Indianapolis, Ind. M. V. MILLER.

* * * *

When Should an Armature Be Scrapped Instead of Repaired?—I shall appreciate it if readers will give me their opinion on the following: If an armature needs new coils, a new commutator and a new shaft, especially if it is of the type that has the laminations stacked on the shaft, is a repair job, with only the laminations for a base, a profitable undertaking? Also, when should the core be junked and new laminations used?

Chicago, Ill. J. E. K.

In the April issue, J. E. K. asked for opinions as to when an armature should be scrapped instead of repaired. In most repair shops the cost of re-insulating a commutator completely and rewinding the armature is from one-half to three-fourths the price of a new one. Since armatures are as good as new after rebuilding it is usually considered better to repair them than to buy new ones.

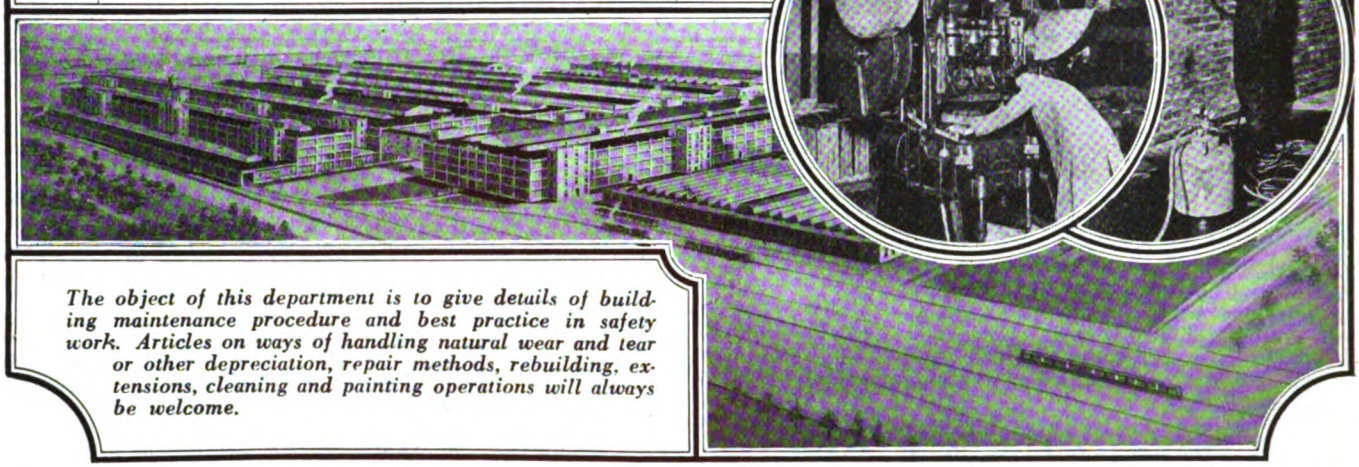
If the armature core is on a spider, a new shaft can generally be put in at a cost not to exceed the price of a new armature. If the laminations are keyed onto the shaft it is generally better to buy a new armature.

It must be remembered, of course, that there is usually considerable delay in obtaining a new armature from the factory, whereas one can be rebuilt in from two to ten days depending on the size and kind. If the iron in the core of an armature gets hot while the winding does not, this is generally an indication that there is an excessive amount of eddy currents, and the laminations should either be re-insulated or junked, preferably the latter.

Peoria, Ill. GEORGE D. RINGNESS.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Gloves from Old Leather Used for Handling Brick

A CREW of yard men, who were inexperienced in handling brick, wore out several pairs of gloves before they learned how to make an efficient and cheap hand protector out of two pieces of leather, 10 in. by 6 in., with a wrist slot at one end and a finger strap riveted at the other. The hand is slipped through the slot until the fingers come under the strap. The stiffness of the leather holds the glove securely in place.

When the brick must be thrown several at a time, from one man to another, such a protector makes for noticeably speedier handling and also helps to prevent sore hands. Old belts, which are not too stiff, can be used by separating the plies so that the leather is not so thick as to be too stiff to use.

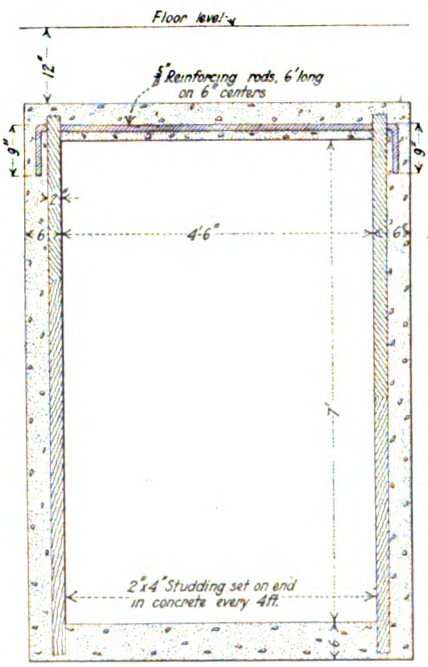
Boulder, Colo. HAROLD E. BENSON.

Construction Details of Tunnel for Conduit and Pipe Lines

IT HAS become common practice to run in tunnels lighting, power, telephone and clock lines, as well as pipe lines for water, air, oil and steam. This simplifies the work considerably when it becomes necessary to repair leaks, replace old sections, install new lines and tap in new branches. The cross-section of a tunnel in one industrial plant is shown in the accompanying sketch. The inside dimensions are 4 ft., 6 in. wide and 7 ft. high, which not only gives plenty of head room, but also allows ample elbow-room for workmen.

The walls, top and bottom are of concrete 6 in. thick with the top only reinforced with ⅝-in. reinforcing rods, spaced about 6 in. apart. The rods are bent near the ends, as shown in the sketch, so as to tie the top into the side walls. Also, 2-in. by 4-in. studs are set in the walls, flush with the inside, about every 4 ft., for attaching the cleats or hangers which are to carry the conduits and small-diameter pipe. These studs should be long enough to reach into the top and bottom slabs of the concrete, to hold them in place. The larger sizes of pipe are run along the bottom of the tunnel, and are supported on suitable rollers to allow free movement due to expansion and contraction.

Manholes with suitable covers are located in the top of the tunnel about every 50 ft., so as to make the tunnel accessible at several points. The ends of the tunnel are fitted with doors through which the long lengths of pipe or conduit can be taken in or out. Wherever necessary, pipe conduits are set in the top of the tunnel through which the wiring and piping lead out into the various departments of the shop. The pipe lines in the tunnel should be fitted with a sufficient number of tees to allow for possible future connections. The wiring can, of course, be tapped at any desired point.



This tunnel for conduit and pipe lines gives ample head- and elbow-room.

The upper surface of the top slab is shown as being 12 in. below the floor line. This allows ample room to install necessary supports, such as sleepers or I-beams, in case a track or driveway has to pass over the tunnel.

Dorchester, Mass. D. FLIEGELMAN.

Advantages of Keeping Diaries on Maintenance Jobs

THE editorial entitled "Job-Diaries on Maintenance Work," on page 491 of the October, 1924, issue was very interesting to us, as we have had such a system as this in operation for about five years. Previous to its installation we found that some question would come up regarding a repair or maintenance job and it would be remembered that this same thing had been gone over before, but no one had saved the exact data on it. This happened so many times that we realized a great deal of time and expense was being wasted in duplicating investigation of the same sort of jobs.

For instance, an order would be received by one of the engineering departments for certain work. The foreman would look it over and then call upon the others interested for a consultation as to the best method of undertaking the job. As a result, from two to six men spent some time in going over the ground thoroughly. We found by experience that this same job would come up again and that it would be necessary to hold another consultation over it, as no one could remember the exact details. Eventually we decided to keep a rough summary of the method used for each job with a notation, when the job was completed, as to how it worked out.

It is impossible to give definite figures as to the savings in money which this plan has made, but we are more than satisfied that it was one of the

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best systems ever started in our shop.

We have found that our cost system helps us greatly in connection with this job record, as we can always turn up the cost card on any job and secure therefrom the itemized list of material used and the labor time. These, together with the diary record, give us a very complete story of each job.

This plan has worked out to advantage in another way, and that is its value as a reference for estimating purposes. When used with the cost records it is invaluable for this purpose. We are often asked for an estimate on a certain job which we know we have done before and without any diary or record it would be necessary to make a very careful estimate of the cost. However, a look over the diary enables us to make sure that the jobs are the same; then, after consulting the cost records, we can easily give a very close estimate.

I would suggest that anyone who is contemplating keeping a job diary, such as described, would do well to tie it in with their cost records in some suitable way. In our case this has been accomplished in a simple manner, as every job of work undertaken is covered by an order number assigned on a work order form. This order number is shown in the job diary and also on the cost records, and thus gives us an easy cross-reference.

L. J. CLAYTON.
Ass't Mechanical Engineer,
The Goodyear Tire and Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

Air Hoist Saves Floor Space in Steel Chip Disposal

THE small portable compressed air hoist so frequently used for a variety of jobs in metal mines and by contractors, may also be put to good service in any machine shop or manufacturing plant. The small space and light weight of these machines, combined with their relatively high power, and ease of control, render them adapted to numerous special purposes.

In the new Sullivan Machinery Co.'s plant at Michigan City, Ind., all manufacturing is done on one floor, covering about 200,000 sq. ft. The problem of disposing of the steel and cast-iron chips, turnings and borings of the machines at once presented itself. The cast-iron turnings and borings were readily handled by providing small portable bins or hoppers, equal to a carload when filled. These are placed at convenient points, and their contents dumped, by means of a traveling overhead crane, into a freight car, which is run into the shop.

Disposing of the steel chips, turnings and borings was a more difficult problem, for the reason that the steel scrap is more bulky, and the chips and turnings are very tenacious, so that they interlock when piled together, making it hard to separate them when the pile was to be loaded onto the car. The item of floor space, as well as expense, precluded the use of a baling press. A platform outside the shop was considered, where the waste might be piled and handled into freight cars by using a self-propelling crane with clamshell bucket. However, this would be expensive to operate, and necessitate wheeling the chips a considerable distance.

As floor-space economy was a prime consideration, the scheme shown in the accompanying illustrations was finally adopted. This utilized the overhead space which had previously been of no value. With that idea in view, a steel bin was constructed at a point where it could be emptied into the freight car at one end of the building. This bin was made tapering on the bottom and smooth inside. Its capacity, roughly, equals that of a gondola freight car. The bottom slope is about 30 deg., so that the chips slide out of their own weight. The top of the bin is flat, and about 26 ft. above the floor level. At the discharge end, the bin is 14 ft. high by 10 ft. wide, and at the small end, 3 ft. high by 7 ft. wide by 25 ft. long over all.

The dotted line on the illustration at the left shows the path of the elevator, which operates in vertical guides, and is provided with a hopper or tray with a capacity of a full wheelbarrow load of chips. The hopper is hoisted by means of a Sullivan, single-drum, turbinair hoist mounted on top of the bin, as shown in the other illustration at the right. The drum holds 500 ft. of ⅝-in. wire rope and has a capacity of 2,000 lb. on single line, direct, vertical lift provided by the 6½-hp. turbinair, helical-geared motor. The hoist is operated by a valve situated above the floor and bolted to one of the guides for the elevator. The wheelbarrow men dump their loads of chips on the elevator trays; then they open the valve and the load is raised and the tray or hopper automatically dumped at the top of the hoist by a trip, similar to those used in dumping mine skips or cages. These are lowered by gravity.

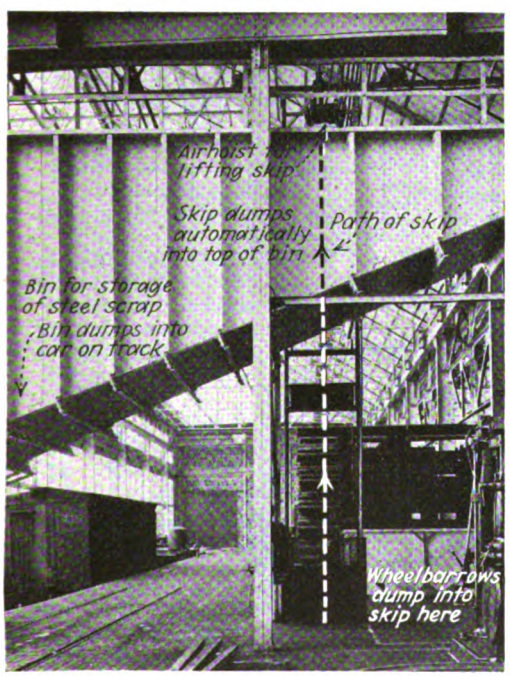
When the bin is full, a car is run under the large end and a vertical door 5 ft. high by 10 ft. wide is opened by means of an air-cylinder hoist, which is shown in horizontal position on the top of the bin in the foreground of the illustration at the right. This door operates like a tail gate on a wagon.

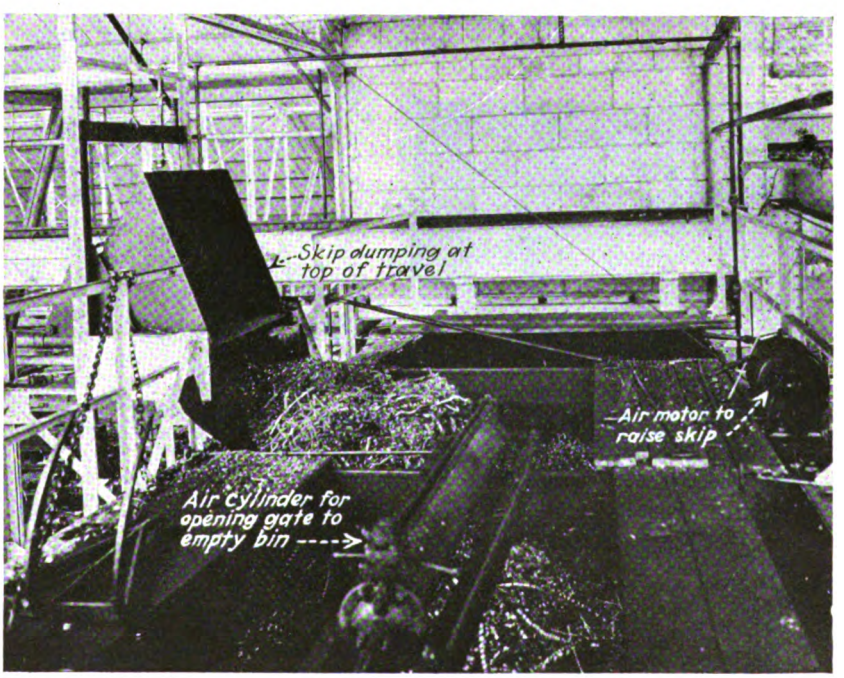
This method of handling chips has saved about 500 sq. ft. of floor space and reduced the cost of handling about 50 per cent.

W. H. WINEMAN.
Shop Superintendent,
Sullivan Machinery Co.,
Michigan City, Ind.

Two views of the equipment for steel scrap disposal at the Sullivan Machinery Company's plant.

Steel shavings are dumped from wheelbarrows into the skip which is lifted by an air hoist, as shown by the heavy dotted line at the left, and dumped, as shown at the right, into the top of this large steel bin, with sloping sides and bottom. This bin holds about a carload and is emptied into gondola cars on the track by opening a gate in the lower end of the bin. This gate is raised by a cylinder air hoist. This method of steel shavings disposal not only occupies a small amount of floor space but it has also decreased the former cost of handling about 50 per cent.



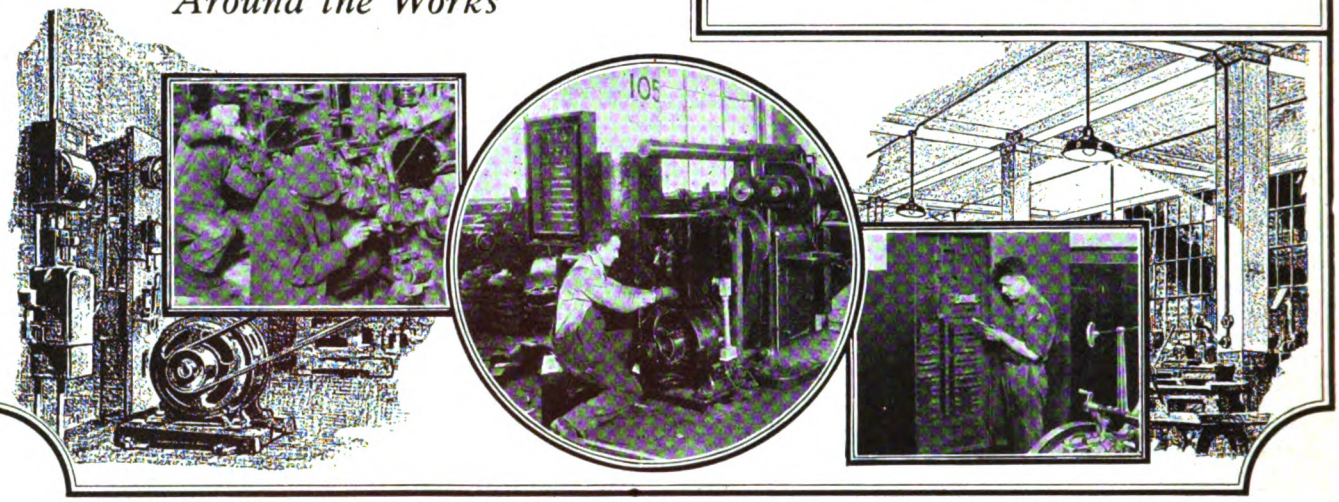


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Electrical Service

Around the Works

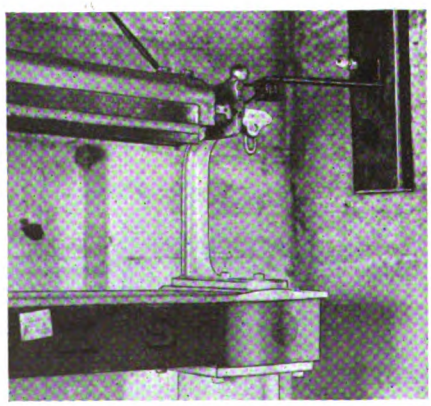
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Contact Device on Scale Beam Tells When Proper Load Is Obtained

LARGE quantities of rough rock salt are shipped in gondola cars from the mines of the Avery Salt Mining Company at Avery Island, La. The cars are loaded by running them over a scale and then starting a motor, controlled by an Electric Controller and Manufacturing Company compensator, which drives a conveyor that dumps the salt directly into the car. Knowing the amount of salt desired in each car, the operator first sets his scale beam to that amount and then takes his position at the loading chute.

On the scale, but in a position that does not affect the accuracy of it, has been placed a very sensitive contactor as is shown in the accompanying illustration. As the scale beam rises to a balance, it closes this contactor and causes a horn to blow. The operator at once shuts off his conveyor motor through a push button switch which trips the compensator.



This contact-making device is located adjacent to the end of the scale beam.

When the scale balances, the beam hits the contact device which closes the circuit on the horn, thus signaling the operator that the proper load has been obtained.

This device could also be used to operate the compensator directly and thus do away with the necessity of the operator listening to the horn and then shutting off the motor himself.

Comment on "Single-Phase Operation of Polyphase Motors"

I WAS much interested in reading W. L. Lodge's comments in the June issue on the article "Single-Phase Operation of Polyphase Motors," and believe with him that it is almost impossible to blow only one fuse of the three protecting a three-phase motor, and thus cause the motor to operate single phase, providing that the fuses are accurately manufactured and *correctly installed*, and motor current is balanced.

However, it is our experience that it is next to impossible to correctly install the 30- and 60-amp. size, ferrule-type fuses, in either the 250- or 600-volt types, due to poor contact of the fuse in the fuse block clips, which point Mr. Lodge refers to in his Item No. 1 under "poor contact." We have a great number of fuse blowouts and also burned cartridges in these sizes, in spite of the fact that fuses are not overloaded and are installed with ordinary accuracy, and believe it is due to the fact that the ferrule contact is not thoroughly satisfactory. A large proportion of them apparently heat enough from the start to draw the temper of the spring to some extent, resulting in poorer contact and more heating, which gets worse until the fuse blows, and finally the cartridge is burned.

It is our opinion that the 30- and 60-amp. fuses should be made with a knife blade contact, the same as larger sizes, as we find no similar trouble with the latter.

We would be glad to see some discussion from operating men and fuse manufacturers on this subject.

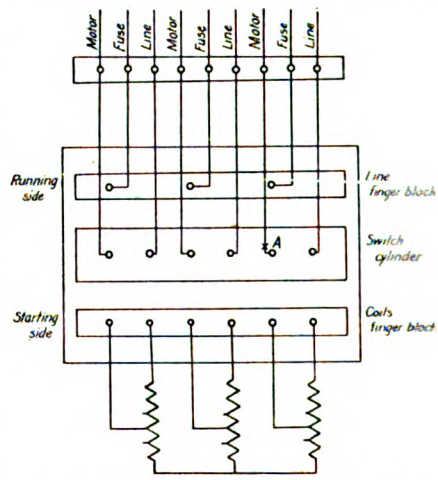
Power Engineer, CHAS. C. COBB, JR.
Walworth Mfg. Co.,
Kewanee, Ill.

Broken Connection Cause of Peculiar Behavior of Three-Phase Motor

RECENTLY a report was brought in to our plant that a 10-hp., three-phase motor driving a quarry drill would suddenly reverse its direction of rotation without warning. As it was impossible to use the drill with the motor running the wrong way, the drill runner would stop the motor; when he started it again it would always start the right way only, however, to repeat the same performance in a short time.

Some of the electricians and others to whom the report was made were frankly skeptical, while the wise ones openly scouted the possibility of such an occurrence. Upon investigation, we found, however, that the report was correct.

The accompanying diagram of the connections to the starting compensator



One of the motor leads was broken at A, causing the motor to run single phase.

Under certain conditions, as explained in the text, the motor would stall and the weight of the drill bit would start it rotating in the opposite direction.

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will help to explain the reason for this behavior. As shown at *A*, one of the motor leads was broken just above the terminal where it goes through the switch cylinder. As the lead was rather short it would make contact by touching on the starting side only. When the switch cylinder was thrown to the running position the contact would be broken but the motor would keep on running, single phase.

In these drills the drill bit is raised and lowered by an eccentric. So long as everything went all right the motor, although running single phase, was strong enough to keep the drill going. If, however, the drill bit happened to become wedged or caught in the hole, the motor would slow down and at times the weight of the drill bit would overcome the torque of the motor before the bit had reached its highest point. The motor would then stop and as the bit is raised by an eccentric the weight would start the motor revolving in the opposite direction, and as it was running single phase it would keep on running until it was stopped by the drill runner. When again started by the compensator the motor would, of course, run in the proper direction.

After the broken lead was repaired the motor settled down to the somewhat more humdrum, but also more useful method of operation we have learned to expect from these faithful servants.

J. H. GALLANT.
Canada Cement Company, Ltd.,
Belleville, Ont., Can.

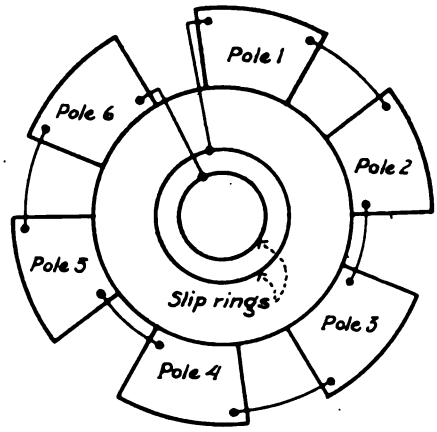
Emergency Method of Operating Synchronous Motor Having Shorted Field Coil

ONE of the troubles that a synchronous motor may develop, is vibration. A machine that has run quietly and smoothly and then develops vibration, indicates either one of two things: misalignment of shaft and bearings, or electrical unbalance due to variation in the magnetic pull exerted by the field. It is advisable, first, to check the alignment by means of a level. If the foundations of the machine have moved, binding will take place in the bearings, accompanied by an increased bearing temperature. If it is found that the bedplate is level, and that the rotating parts turn freely without excessive bearing temperature, it is necessary to look for electrical trouble in the rotating parts.

The means employed to locate the trouble and later operate the machine under reduced load in a case where vibration was rather hard to locate, may be of interest.

The usual checks that were made on the motor indicated that it was accurately lined up. Excessive vibration, however, occurred when the machine was started as an induction motor and the field current applied. Possibility of a short-circuited field coil was apparently discredited, as a voltmeter connected across the individual field coils indicated a uniform resistance for each coil. The machine was then brought up to speed, field applied, and vibration noticed; then the field was cut out, and the machine allowed to coast, when the vibration immediately ceased. This seemed to indicate conclusively that one of the field coils was short-circuited, even though the drop measured by the voltmeter indicated otherwise.

Since a short-circuit between turns in one of the field coils evidently existed when the machine was running, running conditions were approximated by compressing each coil by means of C clamps, the pressure exerted being approximately equal to the centrifugal force due to the speed of the machine. While the coil was compressed the voltage drop across it was measured. This test was unsuccessful inasmuch as it did not show any variation in voltage drop.



Vibration in this rotor was caused by a shorted field coil.

Since the field coil was shorted only while the field was rotating, it was difficult to locate the defective coil. It was found by reconnecting the field coils as described in the accompanying article and then operating the machine to see whether the vibration ceased.

As this was a six-pole machine, it was decided to disconnect the coils on two opposite poles and operate the machine with four salient poles and two consequent poles. In the accompanying diagram, field coils *1* and *4* were disconnected, leaving coils *2*, *3*, *5*, and *6* connected in the field circuit. This connection made poles *2*, *3*, *5* and *6* act as salient poles while poles *1* and *4* became consequent poles. When the machine was operated with this arrangement, no improvement in vibration was noted.

Coils *3* and *6* were then disconnected and *1* and *4* re-connected. Upon starting the machine it was found that the vibration ceased. This indicated that either coil *3* or *6* was causing the trouble. To determine which one of these two coils was at fault, it was necessary to disconnect the even-numbered coils, and operate the motor with the odd-numbered field coils; that is, coils *2*, *4* and *6* were disconnected and the machine operated with coils *1*, *3* and *5*. No vibration occurred on this test. This indicated that coil *6* must develop a short-circuit between turns when it was subjected to compression caused by the centrifugal force of rotation.

It was necessary that this machine operate under reduced load while a new field coil was being obtained from the manufacturer. For several weeks the machine was operated at 60 per cent of its rated load, with four salient and two consequent poles. The maximum load was, of course, determined by the permissible armature and field current, but it was found possible to carry this 60 per cent load with a slight increase over the normal field current and somewhat lower power factor on the motor.

If the field coils are removed from the rotor, it is necessary that the pole pieces remain in the rotor in order to complete the magnetic circuit and maintain the same number of pairs of poles.

The information gained on this job has enabled us to operate at reduced capacity a number of synchronous motors having defective field coils, that would otherwise have been shut down until the new field coil was received.

M. G. REES.
District Service Manager,
Westinghouse Electric & Mfg. Co.,
Detroit, Mich.

Effect of Full-Voltage Starting on Induction Motors

THE effect of full-voltage starting on the windings of squirrel-cage induction motors was discussed by J. T. Rylander of the Westinghouse Electric and Manufacturing Company at a recent convention of the American Institute of Electrical Engineers. His paper gives the results of experimental tests on starting squirrel-cage induction motors on full rated voltage with a study of such starting in service and methods of bracing the end windings. The points of particular interest to readers of INDUTRIAL ENGINEER are abstracted in the following:

It is well known that a heavy starting current is required when starting squirrel-cage induction motors with the customary autotransformer starter. When starting these motors by connecting them directly to the line a starting current that is even heavier is drawn from the line, which, in itself, is undesirable. However, on certain applications it is desirable to have motors start from rest or at some reduced speed without the aid of an attendant when the power on the line fails and then comes on again. This is accomplished by omitting the customary autostarter and connecting the motor directly to the line, thereby impressing on the winding full line voltage, instead of reduced voltages of 50, 65, or 80 per cent.

The effects of full-voltage starting were determined by special tests made on two motors. On these two motors it was found that there was either quivering, vibration or displacement of the windings whenever one of the motors was started. The severity of the motion or displacement increased as a function of the square of the voltage applied to the particular winding; that is, a 440-volt or 2,200-volt motor is no worse off than a 220-volt motor so far as the effect of full voltage alone is concerned, but 440 volts will produce four times as much coil displacement as 220 volts on a particular winding, regardless of the voltage rating.

Starting motors on full voltage pro-

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duces a severe stress for a short period, whereas the use of an autotransformer starter produces a less severe stress for a longer period than when starting with full voltage. The auto-starter may produce two severe shocks on the winding in opposite directions. This is accounted for by the voltage, which is produced in the winding, being out of phase with the line voltage at the instant of changing from the lower-voltage tap to the full-voltage tap of the auto-starter.

Observations made on a number of machines that were subjected to full-voltage starting showed that when the effect on the windings is slight, nothing is seen with the eyes, but any quiver or vibration of the windings is felt with the hands without difficulty. Some of these windings not only vibrated but had a definite movement which lasted as long as the heavy starting current flowed through the windings. These movements of the windings were such as to separate the windings wherever the phases change and to cause the winding to move away from the rotor and toward the frame. When the vibration of the winding is severe, a distinct hum is heard.

Some machines which had been in service for years finally failed due to distortion of the windings. The customary auto-starter method of starting these machines had been used. Whether the cause of the distortion was due to the starting current or to some other disturbance, such as short-circuits on the line near the motor, was not known. These windings showed the following effects:

(1) The windings had separated between phases.

(2) The windings had moved away from the rotor and toward the stator.

(3) The top and bottom layers of coils had drawn together.

The separation between phases and the movement toward the frame was also noticed on some of the windings that were observed while they were being started.

The attraction and repulsion of the conductors on each other tends to move the conductors and is opposed by the mechanical fastenings which support the conductors. Many of the conductors are secured by resting them against other conductors, which are secured by various means. As all armature conductors pass through the slots, the slots are an effective means of securing a large part of each conductor. Beyond the slots a number of the conductors are bound together in a unit as a coil, and this prevents the conductors from vibrating against each other. Each coil end tends to move under the effect of the force exerted on it by all the other coils in the machine, but is resisted by the rigidity of the coil as each coil is held by being placed in two different slots and usually fastened at one or more other places on the ends of the windings by means of rope, bolts, clamps or steel bands to other more or less fixed supports.

In many of the small motors the coils fit closely to each other and the complete winding is reinforced with varnish or impregnating compounds; therefore, their windings are exceptionally well braced to resist the forces exerted when starting the motors.

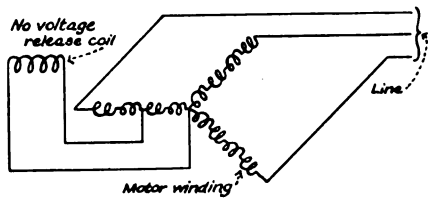
The vibration and movement of the windings deteriorate the insulation, and if sufficiently severe, will cause an insulation failure. They may also break the coil leads.

The kind and amount of insulation and the method of bracing are the limiting factors which determine how much vibration or coil movement can be permitted. The repetition of these vibrations sometimes has a cumulative effect by loosening the rope which is usually used to secure the coils to a supporting ring.

As the amount of vibration or coil movement is directly proportional to the square of the ratio of the starting current to the full-load current, the starting of squirrel-cage induction motors is much more severe on the windings than it is with wound-rotor induction motors, where the current is limited by the resistance in series with the secondary. As the amount of vibration is also directly proportional to the third or fourth power of the length of the coil between supports, very thorough bracing is required where the coil extensions are comparatively large. Nevertheless, there seems to be no question that all induction motor windings can be braced to stand the mechanical effects of full-voltage starting.

Emergency Use of 110-Volt No-Voltage Release on 440-Volt Coil Compensator

RECENTLY, while installing some used motors and compensators, it was found that the no-voltage release coil was burned out on one of the 440-volt compensators. The only spare coil on hand was wound for 110 volts and as the motor which was to be started by this compensator had been connected previously for 220 volts, it was necessary to reconnect it for 440 volts.



By connecting to the neutral and midway between it and a phase lead, 127 volts was obtained for operating a substitute 110-volt, no-voltage release coil on a 440-volt compensator.

It was at length decided to bring out two leads from the winding, as shown in the accompanying sketch. The motor was series-star connected for 440 volts which gives $440 \div 1.73 = 254$ volts from any phase lead to neutral. By bringing out a lead from the neutral point and midway between it and a phase lead, we obtained 127 volts which operated the no-voltage release coil quite satisfactorily.

Construction Engineer, W. L. STEVENS.
Smith Robinson Co.,
Vancouver, B. C.

Installation of Switchboards

(Continued from page 332)

connection is so overloaded that it will endanger continuous operation.

A regular schedule should be prepared for the periodic testing of instruments, meters, relays, and for the inspection of all other equipment. It is advisable to have a card or blank for this purpose in the form of a questionnaire on which can be noted each point as observed.

The switchboard should be cleaned regularly. This may be done by wiping the apparatus on front of the board and the equipment on the back of the board should be cleaned by dry compressed air of moderate pressure from a hose. If this must be done while the board is alive, extreme care must be exercised.

REPAIRING PANELS

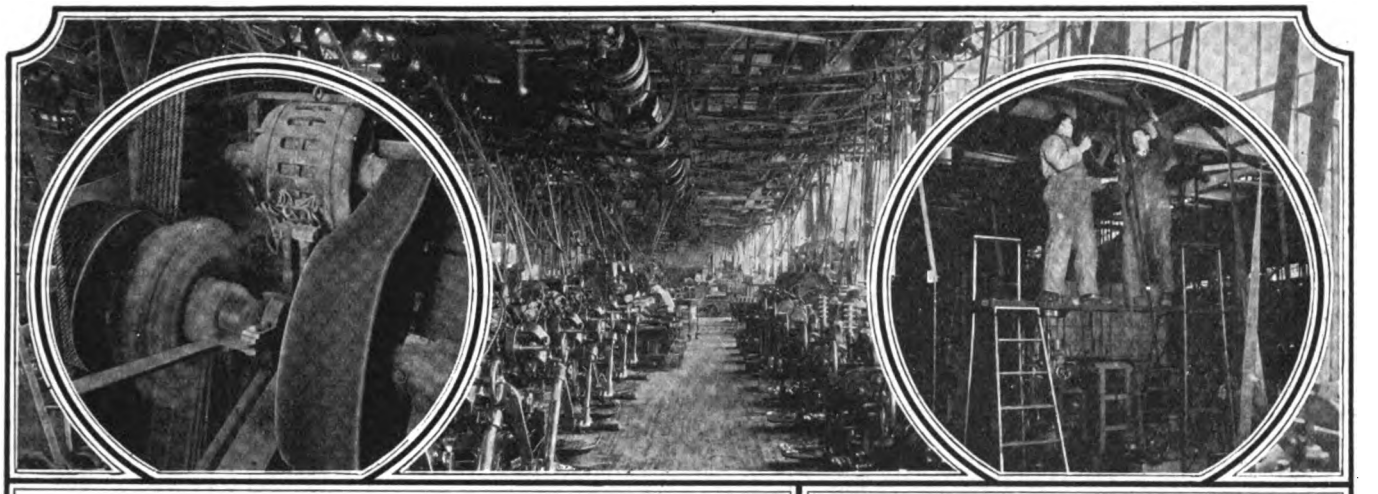
To renew the finish of dull black marine slate, black enamel slate, and marble boards, soap and water should be applied with a soft cloth. A marble panel may also be brightened by rubbing with a cloth dipped in gasoline. Oil stains may be removed from polished marble by applying a mixture of benzine and plaster of paris, letting it remain on the stain for 48 hours. Natural black slate may be restored to its original freshness by rubbing with a soft cloth dipped in good engine oil. Only sufficient oil should be used to bring out the good black color of the slate.

To change the finish of a marble panel to match a slate board, the polish should first be removed by rubbing with pumice stone; the surface should then be sprayed evenly with marine lacquer. If the devices cannot be removed, they should be carefully protected. Marine finish may be removed by rubbing with alcohol.

The same kind of drill is used to drill slate or marble as is used for steel, except that the heel of the drill should be ground off to give the drill a sharper angle. Slate may be drilled dry, but marble should be drilled with water. Care should be taken when the drill is coming through the panel, not to break the back surface by too great a pressure on the drill.

Holes left exposed by changes in equipment may be plugged with Portland cement or plaster of paris colored with lamp black.

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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Adapting Grease Cup to Apply Pressure Lubrication

THE grease holes in conveyor and other bearings where dirt easily works its way in, will sometimes get clogged up and thus render the ordinary grease cup ineffective. In such instances I have either modified the construction of the grease cup so that from four to five times the pressure may be obtained, or else used a steel grip on the cup to help screw in the grease. Then by working in plenty of the grease while the machinery is in operation, the dirt will gradually work its way out and cleanse the grease hole for a time.

Of course, this is not a "cure-all" for these dirt-clogging troubles, but where there is insufficient shut-down time to scrape out grease grooves or to make other permanent repairs to keep dirt out of the bearings, it is wise to keep the modified cup screwed into the grease hole.

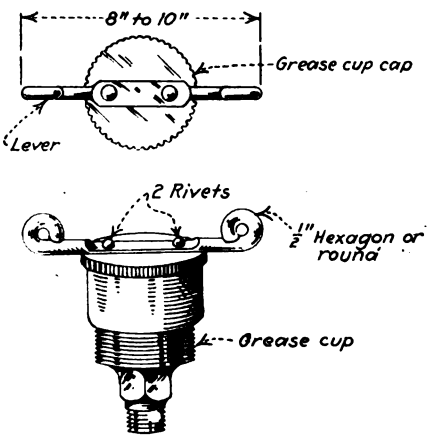
The lever, which is riveted onto the top of the grease cup, is forged out of ½-in. to ⅝-in. round or hexagonal steel to the shape shown in the accompanying sketch, with the ends turned to provide a good hand grip. The central portion where it fits over the cup is flattened out to slightly over ¼ in. thick. This flattening or widening leaves sufficient stock after the rivet holes are drilled out. It may be necessary to provide additional stock by upsetting the steel at this section, as a tremendous bending moment occurs at the rivet holes when forcing the grease through any obstruction.

If the rivet holes are well laid out in both the grease cup and its lever and the riveting carefully done, there will be no decrease in pressure by any grease escaping at this point.

The selection of a grease cup with good threads and a thick shell is of importance, when deciding to modify its construction in this manner, or else the high pressure thus obtained is apt to spring or stretch the shell and cause the cup to jump threads and become ineffective. For this reason, pressed-steel cups are better for this purpose than those made of brass. Cast-iron cups are also good since they are usually made thick, but care must be exercised in riveting the lever on so as not to crack the cast iron.

A handy grip which may be used to screw down grease cups which are close up against a shoulder so that the lever grip shown cannot be used, may be made from a piece of steel bent to fit around the cap of the grease cup, similar to the clamp used to open the common Mason glass fruit jar. This is made by taking a piece of ½-in. round steel about 17 in. long, flattening it out in the center for a distance of about 4 in. and bending this flat part to fit around the grease cup until the ends of the rod are parallel. This leaves two handles each about 8 in. long which may be squeezed to clamp the cap. The flat part may be serrated on the inside to make it grip on the serrations on the grease cup.

Oakland, Calif. S. H. SAMUELS.



By riveting levers on the top of a grease cup, giving it the appearance of a wing nut, higher pressure may be applied than ordinarily is possible when turning by hand.

Lubrication of Ball Bearing Hanger Boxes

WHERE ball bearings are being used in shaft hangers, motors and other power drive equipment, the lubrication requirements are not as well understood as for the plain sleeve bearings. The tendency is to over-lubricate the ball bearings. They operate best when the balls and races are just coated with a film of oil or grease. But since it is not a practical matter to regulate the supply with certainty so closely as this, there is no reason to go to the other extreme and suffocate ball bearings with lubricant. When too much grease is applied too frequently, the new grease will simply force out the old lubricant and provide a place for the collection of dirt and dust and make a messy looking bearing housing. The application of lubricant to lineshaft hanger boxes using ball bearings is recommended not oftener than every three or four months depending how continuously the shaft is actually revolving in its hangers and the load on it. For lightly-loaded shafting not in continuous use, the application of lubricant about every nine months is sufficient.

On the lubrication of ball bearing hanger boxes, the Fafnir Bearing Company, New Britain, Conn., offers the following recommendations and sidelights:

"Fafnir double ball bearing, hanger boxes and other Fafnir transmission units are shipped from the factory containing all the grease which they ought to have for six months under average conditions. In fact we use a little more grease than is needed, believing that it is well to supply an excess of lubricant to guard against possible contingencies while the bearings are new.

"It may seem to the reader that we are going to considerable pains to explain what is really a simple matter that anyone can readily understand with a few words of explanation. However, we know from actual experience

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that the mill or factory operator is apt to be unduly conscious of the presence of his new hanger boxes. It is much the same as it is with the man who has just bought a new car. He listens to every murmur of the motor and his ears are strained for squeaks. After a few miles he thinks the valves may need grinding or, more to the point, that the oil has leaked out of the crankcase. The consequence is that for the first few weeks he makes frequent trips to the service station and asks every question imaginable—and many that surpass his normal thinking powers. But after the strangeness has worn off he never visits the service station.

"It is apt to be much the same with the man who has just installed Fafnir double ball bearing, hanger boxes. He worries too much for fear that they may need oil. If he hears a squeak it may be because the hanger screws have worked loose a little, but after thinking about it he is pretty sure to decide that it is time to grease the bearings. As one mill man said to the writer recently—'I know you said these bearings wouldn't need any more grease for a year, but I'll be darned if I am going to see them ruined.' He had been filling them up with grease every four weeks.

"Finally, we want to emphasize the importance of using a proper lubricant. For ball bearing use, avoid lubricants which are sticky and will gum up the bearings. Never use what is called black strap. Moreover, the lubricant should be free from graphite which will pack in the bottom of the race grooves and interfere with the free rolling action of the balls. Lubricants containing animal fats which are liable to develop acids will corrode and etch the highly polished ball and race surfaces.

"The ideal lubricant is one having a mineral base and which is absolutely neutral,—that is, neither acid nor alkaline. For very slow speeds a grease should be used, and for high speeds, an oil. For Fafnir double ball bearing, hanger boxes used on line shafting, where speeds are usually neither low nor very high, in general a neutral non-fluid oil made from a mineral base, the consistency of which is about like vaseline, is best. There are a number of brands of high-grade lubricants of this character on the market, any one of which will give good results."

Simple Chart for Finding Pulley Sizes to Give Various Speed Ratios

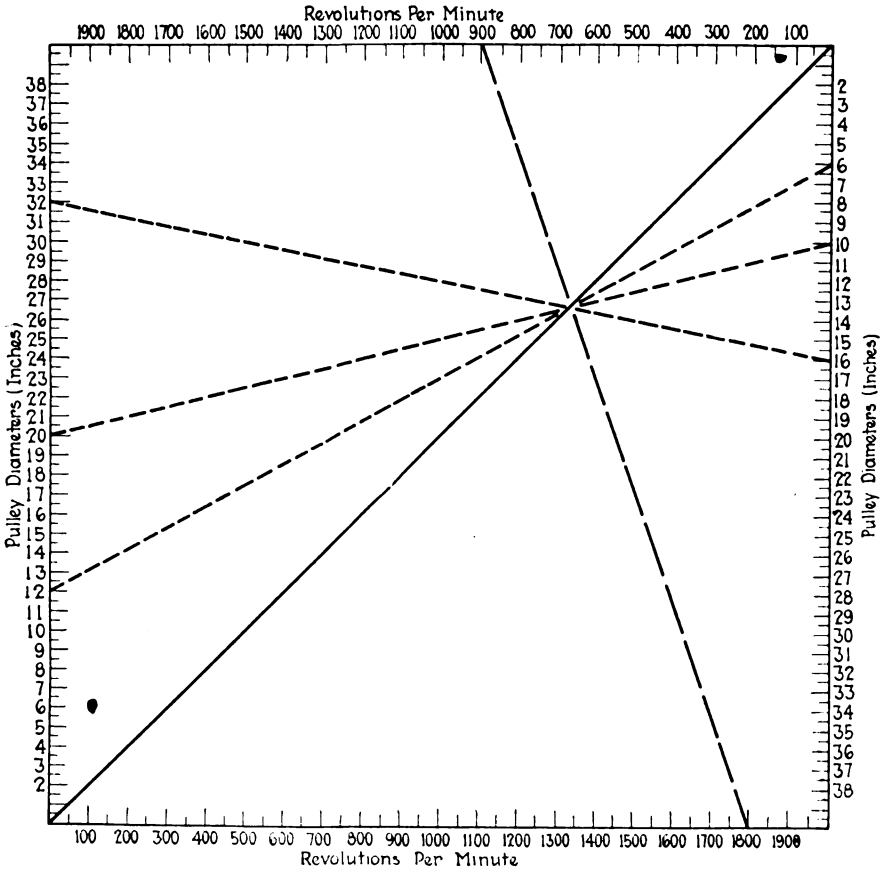
IN MAKING changes in belt speed, it is frequently desirable to make a quick check to see how closely some of the pulleys available will give the desired speed, if used. One method of doing this is by the use of a chart such as is shown in the accompanying sketch. This pulley chart is made up in the form of a square with a scale on which each 100 revolutions are equal to two units representing the diameter of the pulley in inches, arranged as shown.

Suppose that with a motor speed of 1,800 r.p.m., a speed of 900 r.p.m. is desired for the machine which it drives. The first step in locating the approximate pulley sizes would be to place a straightedge on the scale at 1,800 and 900 r.p.m., as shown by the longer dash line. The point of intersection with the diagonal is then used as a center or axis and the straightedge laid through it. When the straightedge passes through this center point the readings on each side indicate pulley diameters which will give this ratio of speed changes. In this way, it is possible to test out quickly a variety of pulley sizes to see if any usable combination can be made up of those on hand.

While this scheme is a part of a recommendation on the calculations used in designing textile machinery, Technologic Paper of the Bureau of Standards, No. 282, the ease with which it may be constructed and used in industrial work is obvious. If this chart is to be used very frequently it would be advisable to redraw it to a considerably larger scale, and with more r.p.m.'s and diameters given. In case it is desired to protect it, the chart may be shellacked which makes it waterproof and easily cleaned. The chart in that case must, however, be mounted on heavy wallboard.

With this pulley chart combinations of pulleys to give any required speed ratio may be easily computed.

To find the combination of pulley sizes which will give a special speed when the speed of one pulley is fixed, simply place a straightedge on the horizontal scales, which represent the two speeds, as shown by the heavy dash line. The point of intersection of the straightedge with the diagonal is then used as a center and the straightedge rotated on this center indicates the possible combinations of pulley sizes which will give the required ratio. Three of the possible combinations are shown by the short dotted lines.



Helps on Running-In Bearings Which Heat Up When New

RECENTLY, I found a way of working down new bearings when they overheat on the first run, without any apparent cause, which may be of service to some other reader of INDUSTRIAL ENGINEER. My remedy for this condition is to pulverize a cake of Sapolio or Bon Ami and mix it with the oil which is being poured into these bearings. This is all washed out after obtaining the desired relief and replaced with fresh, clear oil. On extremely bad cases of overheating with new bearings, I have used Dutch Cleanser.

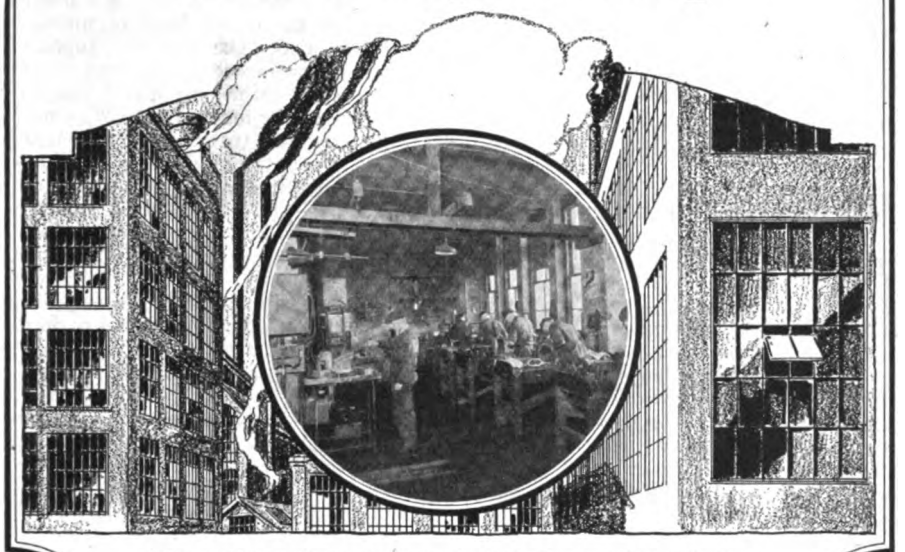
This heating has been attributed to using mandrels which are not perfect and give a somewhat eccentric interior bearing surface. This permits the bearing to turn freely along the shaft but it seemingly freezes on being fastened down in the bearing housing. My experience with graphite is that it does not wash out well afterward and to a great extent remains in the oil pasages within the housing.

One way to clean and reclaim this oil, which contains the Sapolio solution and also that which has been used in washing out the bearing, is to empty it into an old felt hat placed upside down over a large can. The hat acts as a strainer and need only be washed every month or so with gasoline.

Coatesville, Pa. **M. J. E.**

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Dimension Specification for Ordering Stud Bolts

NO MATTER what the product of a factory is there is one element necessary before service in the way of delivery can be given to the purchaser. That element is complete specification data.

Where a product is standardized there is, of course, less chance for misinterpretation of the order than where the product is individual to each consumer. In the case of ordinary stud bolts, for example, it is not unusual for the customer to assume that, in giving the over-all length and diameter of the bolt, he has given sufficient data for fulfillment of the order. Consideration of the following facts will show that this is not true: (1) Proper thread length for both the tap and nut ends of the bolt is essential for its use in a particular case. (2) No standardized length of tap and nut ends is recognized for a given over-all length and diameter of a stud bolt. (3) A large percentage of this type of bolts is special both as to size, and length of thread wanted. (4) Methods of measurement of the length of the tap and nut ends differ; that is, the tap length is measured *through* the point, while the nut end is measured *to* the point. (5) The importance of specifying point measurement is frequently overlooked.

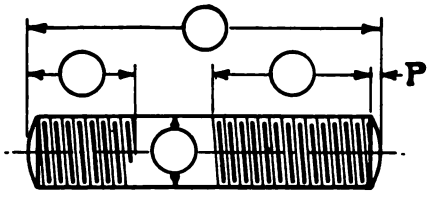
In consequence of the failure of many purchasers to give either sufficient, or the right kind, of information when ordering stud bolts, many bolt and nut manufacturers have developed their own methods of interpreting specifications. Some have even adopted a standard of their own in which a given over-all length and diameter of the bolt represent a definite length of the tap and nut ends. Difficulties attend the use of this, however, as it is not commonly employed or commonly recognized as a standard.

The method which we employ in the case of a customer who orders many special studs, is noteworthy because of its success in eliminating errors. A small blue-print, which is about 4 in. by 6 in. in size and of the form shown in the accompanying illustration, has been made showing the threaded portions, blank area and the points at the end of a stud bolt. The dimension lines, it will be noted, have been drawn in the print for each of these items, but the space for the figures has been left blank. The three items below the stud diagram give the point dimensions (in width) for the various sizes of bolts. It will also be noted that the dimension for the tap end of the bolt extends through the point, while the dimension for the nut end extends only to the point. The dimension for the point itself constitutes a separate item.

A large number of these blank blueprints are kept on hand by the customer. When ordering stud bolts the dimensions desired are filled in on one of these blueprints which is then sent along with the order.

There are several advantages connected with the use of this method of ordering. Briefly, they are: (1) Elimination of all possibility of misinterpretation by the manufacturer. (2) Rapidity with which the dimensions can be filled in. (3) Elimination of time lost in writing the manufacturers for further information.

Buffalo Bolt Co., ARTHUR L. GREENE.
North Tonawanda, N. Y.



"P" = 1/32" FOR 5/16" AND SMALLER
"P" = 1/16" " 3/8" TO 1/2" INCLUSIVE
"P" = 3/32" " 9/16" " 3/4" "
"P" = 1/8" " 7/8" " 1 1/8" "

Use of this form simplifies the specification of stud bolts.

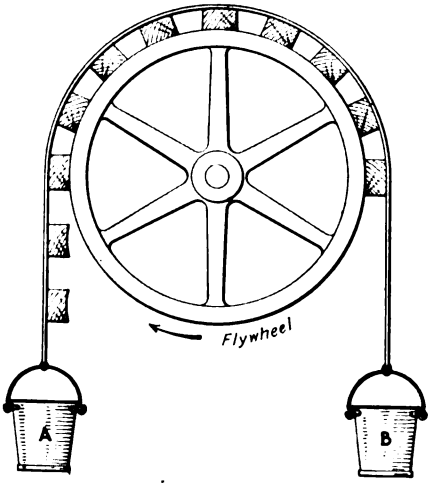
The four important dimensions that should be given are indicated by the circles. The dimension *P* is the width of the point. This dimension has been standardized as indicated in the table under the diagram.

Simple Prony Brake for Testing Small and Medium Sizes of Motors

SOMETIMES, in testing small and medium sizes of re-wound motors, it is desired to subject them to a load test. This is often inconvenient to do because of the lack of a dynamometer or a generator to which the motor may be belted so as to provide a load. When this is true the best method of obtaining a load is by the use of a Prony brake.

A very simple form of Prony brake that can be easily made in the repair shop is shown in the accompanying illustration. The motor to be tested is fitted with a large pulley or flywheel. A piece of leather belting long enough to wrap around the flywheel; as shown in the illustration, is fitted with soft wood cleats. These cleats may be fastened to the belt by means of wood screws. Buckets are then attached to each end of the belt, as shown.

In running the test the flywheel should be gradually brought up to speed and at the same time the two buckets should be balanced by adding iron, bolts, nuts, scrap iron, rock, or other small, heavy objects. Naturally more weight will have to be added to bucket *A* so as to resist the pull of the flywheel on the cleated belt. Weights



The brake is made by fastening soft wood cleats to a piece of leather belt.

This belt is placed around a pulley or flywheel attached to the motor shaft. By adding weight to the buckets which are fastened to the ends of the belt the desired amount of load may be obtained.

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are added to bucket *B* so as to obtain more friction between the flywheel and the cleats, thereby putting more load on the motor. When the desired amount of load has been placed upon the motor, as indicated by an ammeter connected in the supply to the motor, and at the same time the buckets have been made to balance, determine the speed of the flywheel by means of a revolution counter.

The horsepower delivered by the motor at the motor shaft may then be determined by the following equation:

$$Hp. = 3.1416 \times D \times r.p.m \times (A - B) \div 33{,}000.$$

In this equation,

D=diameter of flywheel

A=total weight of bucket *A* and its contents

B=total weight of bucket *B* and its contents

r.p.m.=revolutions per minute of motor shaft

As an example let us say that the diameter of the pulley or flywheel was 2 ft., and that the motor speed was 1,200 r.p.m., when the buckets balanced. The total weight of bucket *A* was found to be 80 lb., while that of *B* was 10 lb. Then the horsepower developed by the motor during this test was $3.1416 \times 2 \times 1{,}200 \times (80 - 10) \div 33{,}000 = 16$ hp.

In making this test it is a good idea to nail strips of wood on the ends of the cleats at two or three points, so as to prevent the brake from slipping sideways.

Some objection to this form of brake might be raised because a downward thrust is placed on the motor bearing by the weight of the two buckets, which will cause increased friction at the motor bearings. This would not be the case if the motor output were determined by the usual form of prony brake. However, this increase in bearing friction is quite small, especially when compared with the full-load rating of the motor. Also, the same increase in bearing friction is encountered when the motor is belted to its load, as the pull of the belt must be borne by the bearings, so that this test will give a close approximation of the performance of the motor under normal operating conditions.

Oakland, Cal. S. H. SAMUELS.

How Babbitt Oil Rings Were Cast and Turned Down

TWO very old motors which were brought in to us for repairs, required, among other things, the replacement of eight oil rings. These were of white metal, which the owner insisted was babbitt and, as he would allow nothing else to be used, we made the rings from genuine babbitt. Because that metal is not very strong and is difficult to handle in the lathe, the method used may help some other readers.

The rings were ⅜ in. wide, 3 in. inside and 3½ in. outside diameters. A mandrel was made by cutting a piece of oak about 1 ft. long and putting big centers (regular 60-deg. bevel) in each end. These centers were large enough to stay true when turning and changing in the engine lathe. This mandrel was turned to a diameter of 3 in. for more than half its length and carefully smoothed up.

In order to make good, solid rings, it was decided to stand the mandrel vertically and to surround it with a piece of steel tubing, 3¾ in. inside diameter. This tubing was smoothed inside with emery cloth to make it slippery and was painted inside with red lead. Both tube and wooden mandrel were faced square on one end, so that they could be clamped upright on the planer table, and centered with a scale. The babbitt was then poured.

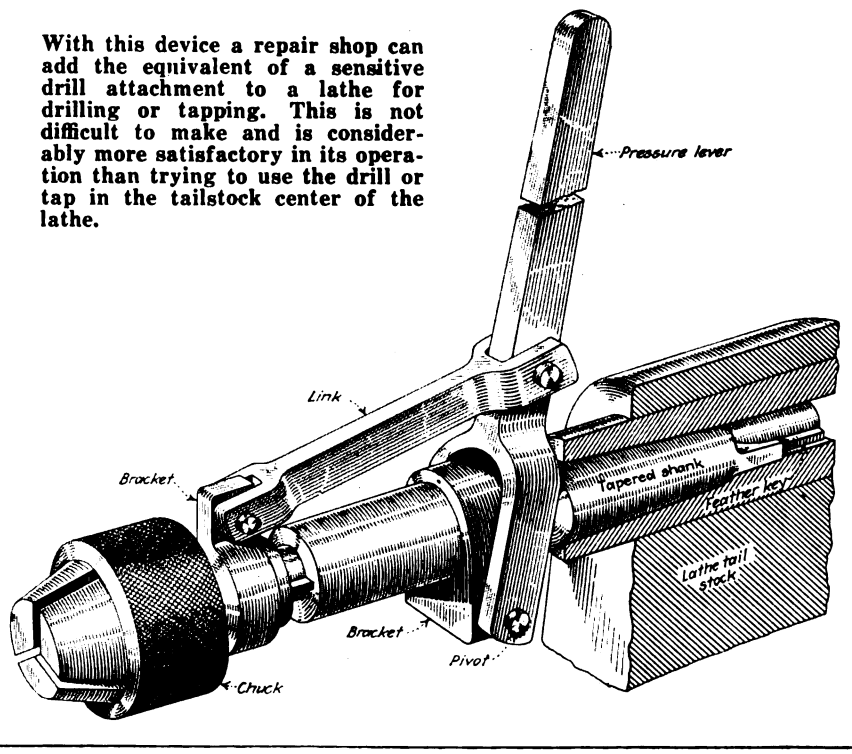
After the tube had been pressed off, it did not adhere tightly to the babbitt, due to contraction of the latter and the coating of red lead on the inside of the tube, the shell of babbitt remained on the wooden mandrel. This was put in the lathe and was found to run as true as when turned. The excess babbitt was turned off until the shell was concentric and reduced to the required diameter. The roughness of the wood and the contraction of the metal were sufficient to hold it in place for turning.

Finally, a ⅛-in. parting tool was used to divide the shell into rings. Thin slices of babbitt-bound wood were then cut off with a hacksaw. The wood centers were removed by drilling a few holes and splitting out with a knife. The slight roughness inside was smoothed with a scraper and the rings were ready. It was a matter of satisfaction that these rings were made without distorting them and that they ran perfectly when put into service.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Easily Constructed Sensitive Drill and Tapping Attachment for Lathe

With this device a repair shop can add the equivalent of a sensitive drill attachment to a lathe for drilling or tapping. This is not difficult to make and is considerably more satisfactory in its operation than trying to use the drill or tap in the tailstock center of the lathe.



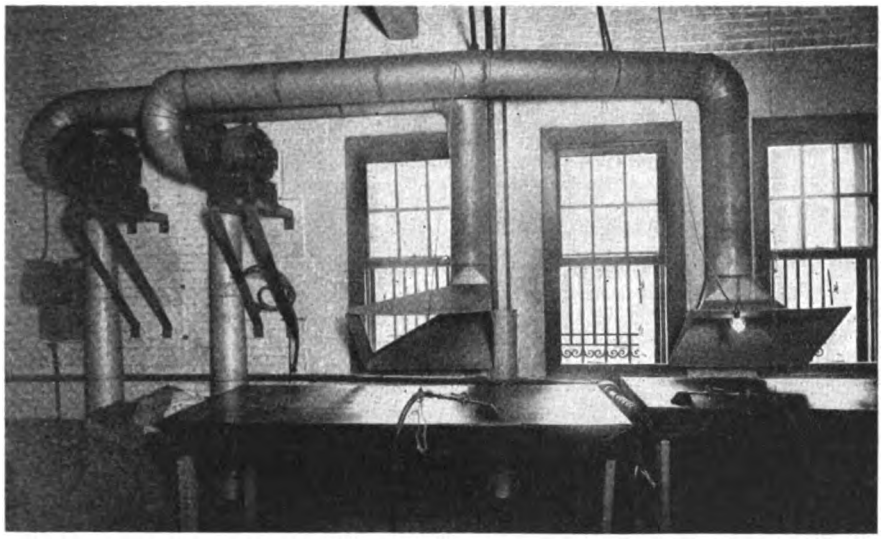
SMALL repair shops often do not have an extensive line of machine tools and the ingenuity of the men is frequently taxed to devise special attachments for doing unusual work. One operation, for example, which they are frequently called upon to do, is to drill or tap parts in the lathe. In shops without special attachments the usual method of drilling with the lathe is to place the drill in the tailstock spindle and use the tailstock feed to move the drill into the work. It is more difficult, however, to use a tap in the tail stock of the lathe in this way on account of the tendency of the tap or chuck to pull out of the socket when backing off.

One means of attaching a sensitive feed to the tailstock of a lathe is shown in the accompanying sketch, which illustrates a device which one repair shop man made to do this kind of work. As will be seen a chuck is mounted on a solid shaft, with a feather key to prevent it from turning. The connection to the lathe spindle is made through a hollow tapered shank of the usual size. The key is also attached to this shank. A single link and a pressure lever are fitted with small brackets, as shown in the sketch at the left.

The drill or tap is moved forward by the lever, without forcing, and only as required. The parts comprising this device are simple and do not require any difficult machine work or the making of any castings. Drilling and tapping operations may be carried on with this fixture with a facility equal to that afforded by the sensitive drill press, which makes it a very desirable lathe fixture for general use.

Washington, D. C. G. A. LUERS.

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Hoods and exhaust systems on a fur cleaning bench.

Each bench is supplied with its individual exhaust system and outlet so that either may be used irrespective of the other. The hoods catch any dust or hair which may be loosened during the cleaning process and draw it away from the operator before it escapes into the room. The suction brush which is used for cleaning the fur is on a separate exhaust system, as it requires a much higher suction pressure than is needed for the hood.

Removing Dust in Industrial Plants

(Continued from page 326)

employed, and suctions less than the maximum noted above will be the rule, in the average case.

Centrifugal exhausters used for this class of work are generally of the stage or turbine type, in which a number of narrow fan wheels are mounted side by side upon the same shaft, so as to operate in series, the same as a centrifugal pump with multiple impellers. Low-pressure exhausters of this type are commonly designed for suctions up to 25 or 30 in. of water column, and high-pressure machines for 100 in.

Another form of exhauster used quite extensively in this work is the rotary type. This is a positive-pressure machine, and some forms are capable of operating satisfactorily under pressures up to 5 or 6 lb. per sq. in.

Pneumatic sweeping is made use of in all kinds of factories and mills where fine dust and lint settle upon the building construction and its contents. Its advantages are obvious, as it sweeps without raising a dust, and collects the waste material for disposal without moving it from place to place within the room. Sometimes, however, in certain places difficult of access around shafting and in intricate machinery, such as motor or generator windings, it is necessary to blow the dust or lint out with a jet of compressed air and then collect it with the sweeper. This is best accomplished by a jet of air, not exceeding ⅛ in. in diameter, under a pressure of about 30 lb. per sq. in. For some equipment this pressure is too high. Jets from compressed air lines are sometimes used. However, as compressed air generally contains moisture, it is not safe to use around live electrical equipment. Also, the pressure is generally too high although many plants use it.

When employed in textile mills for cleaning machines and shafting, the air current should be directed downward, in which case the heavy lint will fall directly to the floor without being blown about the room. Equipment for this purpose is usually of the portable type. Similarly trucks are equipped with pneumatic sweeping equipment, this being much cheaper in many cases than installing an extensive system of piping connected with a stationary plant. Sweeping and blowing machines are often combined in the same unit by the use of valves for reversing the flow of air through the inlet and outlet pipes.

Types of portable hand blowers and one combination portable blower and vacuum cleaner are available for this purpose. These are attached to a light socket and held in the hand while the blast of air is directed into the machine through a long

Table I—Minimum Sizes of Branch Pipes for Emery or Other Grinding Wheels

Diameter of Wheels	Maximum Grinding Surface in Sq. In.	Minimum Diameter of Branch Pipe in Inches
6 in. or less, not over 1 in. thick	19	3
7 in. to 9 in., inc., not over 1½ in. thick	43	3½
10 in. to 16 in., inc., not over 2 in. thick	101	4
17 in. to 19 in., inc., not over 3 in. thick	180	4½
20 in. to 24 in., inc., not over 4 in. thick	302	5
25 in. to 30 in., inc., not over 5 in. thick	472	6

Note:—The sizes of connections suggested for grinding and polishing wheels are those given in the tables by the Department of Labor of New York, with the exception of those for polishing wheels 21 in. and over in diameter. Specified pipes are without fractional inch diameters to agree with common practice.

Table II—Minimum Size of Branch Pipes for Buffing, Polishing or Rag Wheels

Diameter of Wheels	Maximum Grinding Surface in Sq. In.	Minimum Diameter of Branch Pipe in Inches
6 in. or less, not over 1 in. thick	19	3½
7 in. to 12 in., inc., not over 1½ in. thick	57	4
13 in. to 16 in., inc., not over 2 in. thick	101	4½
17 in. to 20 in., inc., not over 3 in. thick	189	5
21 in. to 27 in., inc., not over 4 in. thick	338	6
27 in. to 33 in., inc., not over 5 in. thick	518	7

Note:—Where the branches are extremely long, the friction loss in the system may be decreased by making pipes ½ in. greater in diameter than the sizes given in above tables.

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nozzle. They are designed primarily to clean electrical apparatus and to remove the dust or lint which settles in the windings. It would be almost impossible to remove this in any other way. Switchboards, relays, and other electrical equipment are also cleaned in the same way. The use, however, of these blowers is in no way restricted to electrical equipment.

Methods of removing the dust from the air supply and the exhaust system, which require the use of filters, will be taken up in another article to appear later. The problem of handling heavier materials such as shavings, cotton, wool, bark and so on will also be discussed in a later issue.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and other articles which are appearing in this series: The Air Conditioning & Engineering Co., St. Louis, Mo.; Allen & Billmyre Co., Inc., New York City; American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; E. B. Badger & Sons Co., Boston, Mass.; Bentz Engineering Corp., Newark, N. J.; Buffalo Forge Co., Buffalo, N. Y.; Carrier Air Conditioning Co. of America, Buffalo, N. Y.; Carrier Engineering Corp., Newark, N. J.; The Clarage Fan Co., Kalamazoo, Mich.; The Cooling Tower Co., Inc., New York City; The Dust Recovering & Conveying Co., Cleveland, Ohio; Globe Ventilator Co., Troy, N. Y.; Green Equipment Corp., Chicago, Ill.; Holly Pneumatic Systems, Inc., New York City; Ilg Electric Ventilating Co., Chicago, Ill.; The MacLeod Co., Cincinnati, Ohio; The Martindale Electric Co., Cleveland, Ohio; Mellish-Hayward Co., Chicago, Ill.; Midwest Air Filters, Inc., New York City; The Northern Blower Co., Cleveland, Ohio; Reed Air Filter Co., Inc., Louisville, Ky.; Spray Engineering Co., Boston, Mass.; B. F. Sturtevant Co., Boston, Mass.; The Temco Electric Motor Co., Leipsic, Ohio.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Wall Receptacles—Bulletin 53 describes the wall receptacles, plugs and cable connectors made by this company for use in industrial plant and other buildings.—Russell & Stoll Co., 53 Rose St., New York City.

Repair Parts for Meters—Part List 9, gives the price list of repair parts for Type H watt-hour meters and single-phase and polyphase meters, service and switchboard types.—Sangamo Electric Co., Springfield, Ill.

Speed Reduction Units—A booklet entitled, "Speed and Power," describes and lists the Boston herringbone and worm gear speed reduction units.—Boston Gear Works Sales Co., Norfolk Downs, Mass.

Lift Trucks—A 12-page bulletin describes the four-wheel Plimton elevating-platform hand-trucks which are manufactured in 33 sizes. The front wheels are mounted on automobile type steering knuckles.—The Plimton Lift Truck Corp., Stamford, Conn.

Snap-Switch Rheostat—A folder describes a combination snap-switch and rheostat for use in connection with small fans, buffers and grinders, small lathes, winding machines, lamps and motors, soldering irons, glue pots and other appliances.—National Electric Controller Co., 154 Whiting St., Chicago, Ill.

Machine Molded Gears—A folder shows how the Poole machine molded gears are made and illustrates some of the variety of gears manufactured in this way.—The Poole Engineering & Machine Co., Baltimore, Md.

Chains and Gears—Section 27 is a 224-page catalog of the chains, sprockets and gears designed and supplied by this company for use in connection with their conveyors and other equipment.—Stephens-Adamson Mfg. Co., Aurora, Ill.

Wood Boring Machines—Literature describes a new lightweight, reversible pneumatic wood boring machine which is suitable for boring holes up to 1 in. in diameter.—Ingersoll-Rand Co., 11 Broadway, New York City.

Non-Metallic Heating Elements—A technical bulletin describes the Globar non-metallic heating unit, gives charts and tables of ratings and shows a large number of standard types of elements used in the electric heating field.—American Resistor Co., Milwaukee, Wis.

Hollow Seamless Balls—Folders describe the method of manufacture of hollow seamless balls made in one piece from steel, brass, bronze, copper, aluminum, monel metal, stainless steel, or any other metal, together with some of the applications.—Hollow Ball Co., Inc., Baltimore, Md.

Automatic Cable Take-Up Reel—Bulletin 1000 describes the C.A.W. automatic cable take-up reels for handling and preserving cable, such as is used on lifting magnets and other portable electrical equipment.—Cleveland Armature Works, Inc., 4732 St. Clair Ave., Cleveland, Ohio.

Truck Casters—Catalog K-8 describes the various types of anti-friction truck casters which are provided with ball races in the swivel and roller bearings in the wheel. One type has both ball and roller bearings in the swivel.—Bond Foundry & Machine Co., Manheim, Lancaster County, Pa.

Roller Bearings—A folder describes utility roller bearings which are made in standard sizes for general use, and gives dimensions and price lists.—Rollway Bearing Co., Inc., Syracuse, N. Y.

Safety Ladder Shoes—A folder describes a cork-grip, non-slipping safety shoe for attaching to the foot of ladders. When attached, this shoe is hinged so that it does not interfere with the use of the ladder.—The Safety Service & Engineering Co., 5716 Euclid Ave., Cleveland, Ohio.

Storage Batteries for Trucks and Tractors—A 16-page booklet entitled "The Adaptability of Electric Industrial Trucks and Tractors" illustrates and describes some of the numerous applications of electric trucks and tractors. A 28-page booklet entitled, "Selecting a Battery for Electric Industrial Truck Service" gives the points to be considered in selecting a battery for this type of equipment, shows by means of charts the operating characteristics, and discusses electrical efficiency, maintenance care and cost and other battery problems.—The Electric Storage Battery Co., Philadelphia, Pa.

Waterproofing Treatment for Belts—Circulars describe Belt-Sek which is a special belt treatment that can be applied to belts on the pulleys for waterproofing them. In addition, it is claimed that this treatment will lengthen the life, prevent slipping and clean the belt as well as put new life into dry, brittle or cracked belts. Other circulars describe different products which waterproof and preserve canvas, cotton textiles, and other fabrics and materials.—Sek Manufacturing Co., 4301 W. Kinzie St., Chicago, Ill.

Handbook of Mechanical Rubber Goods—A handbook of 160 pages describes the various Goodyear mechanical rubber products such as belts, hose, packing, molded and lathe cut goods; 56 pages are devoted to a discussion of Goodyear belting, its applications, methods of fastening, care, how it is made and its use.—Goodyear Tire & Rubber Co., Akron, Ohio.

Wiring Manual—A 150-page, pocket-size handbook contains tables and a large amount of data for ready reference by electrical engineers, contractors and wiremen, in addition to information regarding Simplex products.—Simplex Wire & Cable Co., 201 Devonshire St., Boston, Mass.

Safety Switches, Wiring Devices, Switch and Panelboards—Catalog 13 is divided into four sections, taking up the following subjects: safety switches; open knife switches and accessories; porcelain wiring devices, panelboards and cabinets. This catalog contains 195 pages including the index, and gives a number of diagrams as well as descriptions and illustrations of the equipment.—The Trumbull Electric Mfg. Co., Plainville, Conn.

Care of Rope—Pocket size circulars explain the proper care of manila rope, show how to uncoil it and give a price list.—Columbian Rope Co., Auburn, N. Y.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

August, 1925

McGraw-Hill Co., Inc.
Chicago, Ill.

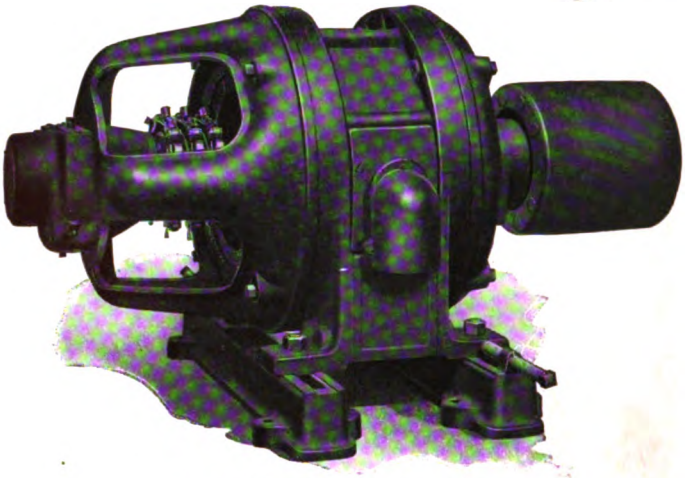


Electricity's Safety Valve

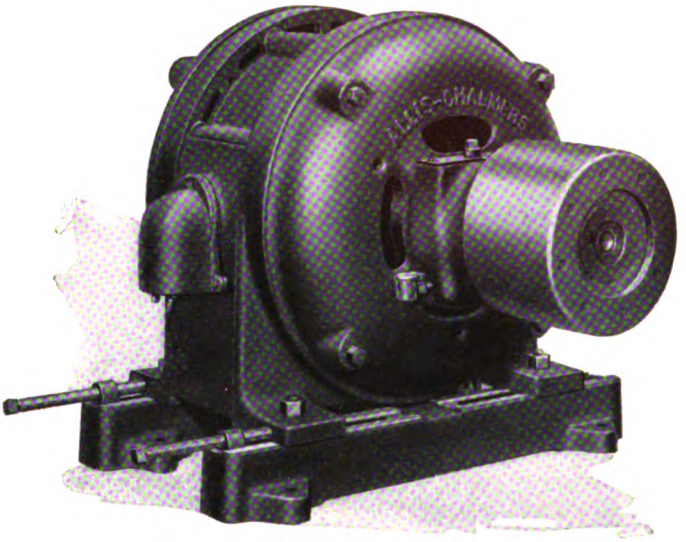
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ALLIS-CHALMERS

Polyphase Induction Motors



Type "ARY" Slip Ring Motor



Type "AR" Squirrel Cage Motor

Constant and Variable Speed

60 and 25 Cycle

Type "AR" and "ARY" motors are designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

They are of the riveted steel frame type. The stator end frames and feet are integral and are made from electric steel castings, insuring a very rigid construction and eliminating any possibility of broken feet.

The method of ventilation is very effective, resulting in even cooling and avoiding "hot spots."

Shafts are very rigid and stiff, while bearings are of liberal design with spacious oil wells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish, making the whole structure dust and moisture-proof.

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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When You Dance Some One Pays the Fiddler—

You May Think It's Not Yourself, But You Can't Fool the Other Fellow



ONE of my good friends and one time pal who is now engaged in a new line of work that is about 90 per cent engineering and 10 per cent salesmanship, has written me some of his experiences that are interesting, amusing, and pathetic. I'll pass them on to you and you can draw your own conclusions and morals.

One case that he ran into involved a blower installation for a school, that called for a 62½-in. wheel overhung on the shaft, with a pulley center hung for belt drive; so it was specified by the architect and approved by his consulting engineer. It came to light that space limitations along the axis of the shaft were the reason for this stipulation in construction. A suggestion to turn the blower around just 90 deg. so as to use a standard blower construction with overhung pulley and center-hung wheel, saved just about $100 on the installation and 17 per cent of the cost of the standard blower.

In another case a consulting engineer selected for a school, a blower with a 43¾-in wheel to deliver 22,300 cu. ft. of air per min. with an outlet velocity of 2,400 ft. per min., in order to save $128 over the next larger size wheel that would operate quietly with an outlet velocity of 1,800 ft. per min. But the first wheel was installed, to whistle a tune of false economy and poor engineering judgment to school children during the next couple of decades.

In addition to that a slow-speed motor, instead of a standard 1,200-r.p.m motor that could have been used, was selected for the belt drive and "blooey" went the $128 saving and some more along with it. But the written word of the architect in his specifications is law, with automatic enforcement, and the contracting engineer adds 10 per cent on a school job and we pay for it in our taxes, with a grunt perhaps, but that's all.

Here's another case my friend writes me about that is funny. A steel mill engineer wanted to drill ⅞-in. holes in mild steel columns 1½ in. thick, and selected two competing drills to try out. Both were put to work on the job about the same time. One had a high spindle speed and the other had a low spindle speed of about 300 r.p.m. The slow-speed drill went to work and just drilled holes with long, curled-up shavings. The high-speed outfit drilled holes, too, and a little faster at the start; so the lazy, slow-speed drill was laid aside and the other one set to work. Two weeks later the high-speed drill was forced out of commission. The slow-speed drill was again pressed into service and finished the job and is ready for another.

This merely goes to prove that, as has been said many times before in INDUSTRIAL ENGINEER, the life of a piece of equipment depends altogether on the judgment of the man who selects the equipment, the consideration he gives to the work that it will be required to do, the attention and care given to it, and the intelligence displayed by the operator in the use of it.

Well, these are only sketches from the back stage of the interesting drama of engineering life—things the folks out front who pay the price do not see. And yet they believe they are getting their money's worth, and perhaps they do. If we all knew what our mistakes were going to cost us, few of us would ever dare to do anything worth while. It's the lesson of the experience that counts in the end, and I hope you will get a pointer if you need it from what I have passed on to you here from my friend.

Practical Pete

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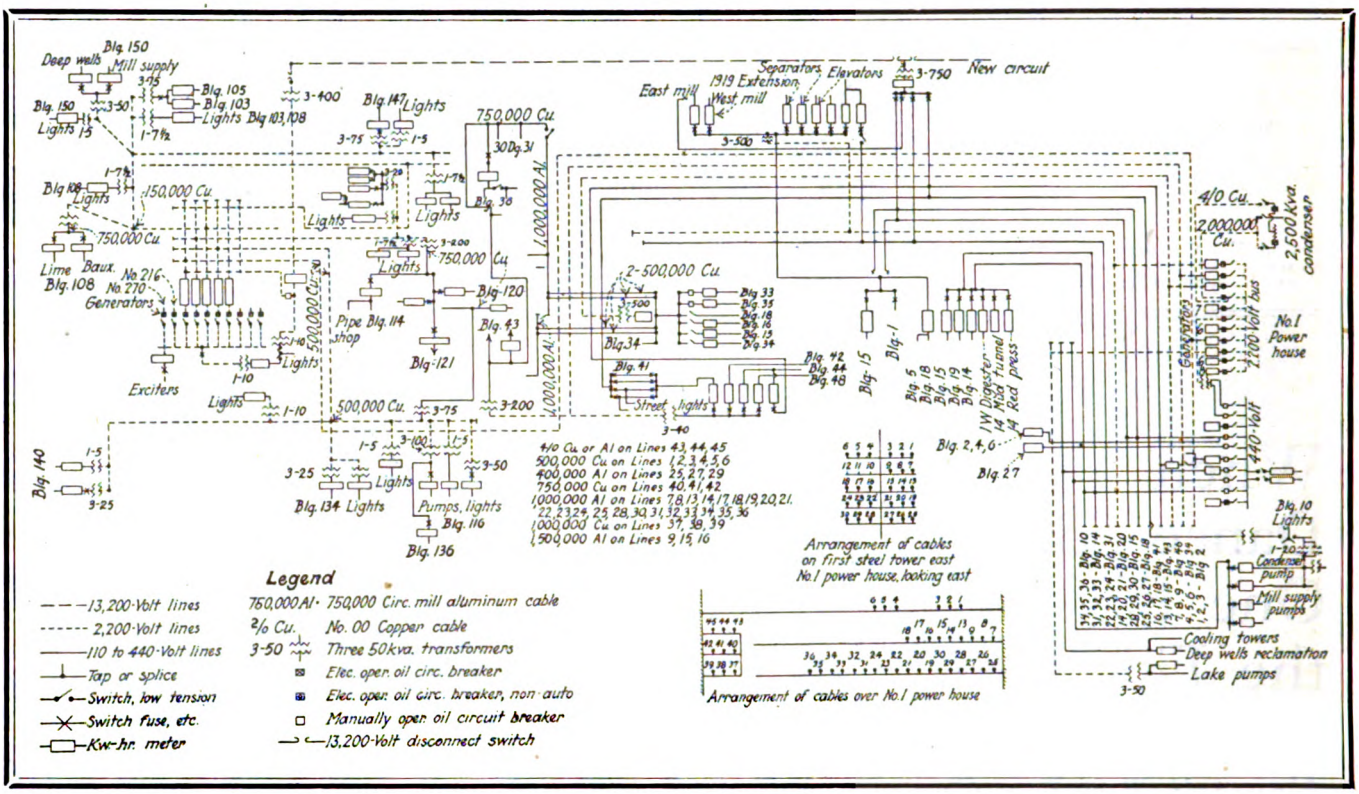


Fig. 1—There is no uncertainty as to where and how the various circuits are run in this plant.

This one-line diagram of the alternating-current circuits is kept up to date by revisions as soon as any changes are completed. Among the various items listed on this diagram are the size, kind and location of conductors, capacity and location of all transformer banks, location of all switches and circuit breakers and what they disconnect, location and number of all watt-hour meters, including the circuits on which the meters measure the power, and much other useful information regarding the system, which should not be left to someone's memory. At the lower center of the diagram is shown the arrangement of the cables as they leave the power house. This is also shown in Fig. 2. The arrangement of the cables on the first steel tower is likewise illustrated.

Considerations That Affect the

Layout of Overhead Electrical Circuits

In Industrial Plant Yards From the Standpoints of Continuity of Service, Safety to Workmen, Cost of Maintenance and General Appearance

By J. ELMER HOUSLEY

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PLANNING the layout of the overhead yard circuits must be given careful consideration if their expansion is to be orderly, safe, and of satisfactory appearance. Naturally, the first consideration is continuity of service, which is followed by safety, provision for future growth, and appearance.

Some plants have all their power distribution and communication circuits underground. This is undoubtedly a very satisfactory place for them; however, the expense is greatly increased. In case the plant covers a large area, and the different parts do not use very large amounts of power, the cost is often prohibitive. In this article we will consider only the overhead circuits, as they are the more widely used of the two systems in industrial works today.

The usual industrial plant yard circuits may be differentiated by two terms: general circuits and local circuits. General circuits usually cover the entire plant area and require the greatest amount of tower or pole space and in consequence require more thought in providing for future expansion. These lines will usually consist of 2,200-volt power circuits, series lighting circuits, telephone circuits, clock, fire alarm, signal and code call circuits. The local circuits are power circuits of low voltage and consequently cover a limited area. These circuits are the 220/110-volt parallel lighting circuits, the 250-volt d.c. power circuits, the 440- and 550-volt power circuits and underground distribution circuits for various services under special conditions which may be peculiar to a given plant.

A one-line diagram of the power circuits in a large plant is shown in Fig. 1. In this diagram the dotted lines represent the 2,200-volt circuits. These are general circuits and extend over the entire plant. The full lines in this diagram represent the 440-volt power circuits. As can be seen the latter lines run only a short distance from the transformers from which they originate and, therefore, they are considered as local circuits.

The main plant power feeders of an industrial plant usually carry 2,200 volts and extend from the power house or substation to vari-

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ous load centers in the plant. Steel towers and steel poles are preferred for the main plant lines because of permanence, ease of climbing, appearance and reduced fire hazard. The 2,200-volt circuits are run on the uppermost crossarms, as is indicated in Fig. 5, in order to eliminate the necessity of small lines crossing the 2,200-volt circuits and the resultant danger of falling on them during storms or during erection. The 2,200-volt conductors naturally must be large enough to carry the load intended for them, but should not be smaller than No. 6 hard or medium-hard, drawn copper or No. 4 steel-reinforced aluminum cable. The conductors should be insulated with a triple weather-proof braid when used within the plant boundary. Smaller conductors are likely to break and allow the high-voltage lines to come in contact with the low-voltage circuits. The braid offers no protection against shock at this voltage but it protects the cable during erection and minimizes the damage to the cable from arcing should a yard crane or other object come in contact with the line.

The line insulators are preferably made of porcelain as this material withstands leakage current to a high degree. In almost any plant a certain amount of dust will accumulate on insulators and to prevent insulator breakdowns an insulator rated at not less than 6,600 volts is used on the 2,200-volt circuits when operating under the best conditions. Where various chemicals are present in the air the writer has found it necessary to use an insulator rated at 17,000 volts in order to eliminate service interruptions and burned-off cables. For dead ends, a single disc insulator 7 in. in diameter and having a voltage rating of 10,000 volts has been found to give best results under ordinary conditions. For bad conditions two such units may be used in series.

For outside work, high-tension braided cable in conduit is sometimes used but deterioration is rapid and many service interruptions result. A better method, especially for connecting the 2,200-volt circuits to transformer banks located at the base of the tower or in an adjacent building, is to install a cable pothead at the top of the tower and run lead cable from this pothead to another located at the transformer bank. Iron conduits should be installed for the protection of the cable for a distance of 10 ft. up the tower and where the cable is underground.

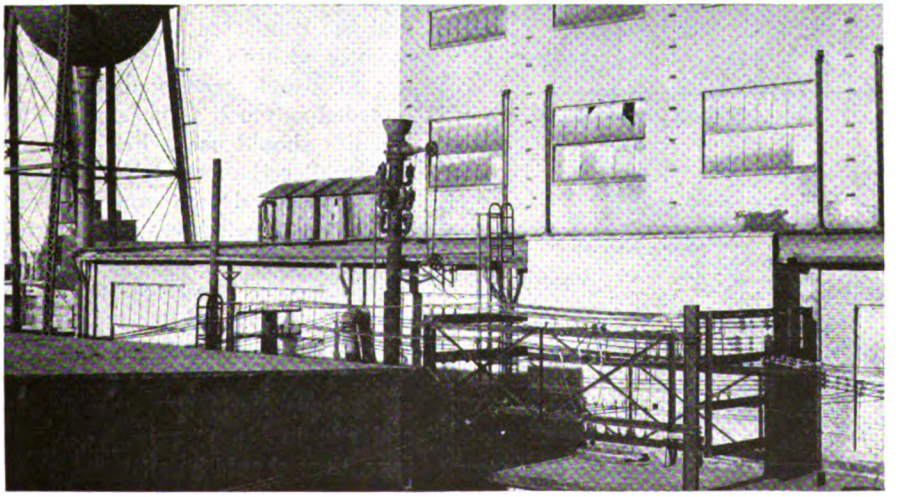
ON WHICH crossarms should the various electrical circuits be located, in the overhead distribution system in an industrial plant? What kind of poles, what type of insulators, and what are the minimum sizes of wire that can be used for this work? Should the wires be insulated or bare? Ought the lighting transformers to be located on top of the pole? What is the most satisfactory way of running the service from the pole line to the power transformer bank? In this article Mr. Housley answers these and many other questions on layout of plant yard circuits.

Disconnects and oil switches should not be brought within 22 ft. of the ground unless suitably enclosed to prevent accidental contact with live parts. For sectionalizing the service in the plant yard, pole-top, air-break switches of good design may be obtained and where overload protection for branch circuits is desired Schweitzer & Conrad high-tension, chemical fuses may be incorporated with the switch as shown in Fig. 7. Where only overload protection is required and it is unnecessary to switch under load, fused disconnecting switches similar to those shown in Fig. 3 may be used. These disconnects can be opened under no-load conditions only, yet they provide overload protection through the high-tension fuses. For metering such branch circuits outdoor-type current and potential transformers are installed at the top of the tower and the secondary leads run in conduit to a metal meter cabinet conveniently located near the ground. The frame of this cabinet must be grounded.

The 2,200-volt circuits should cross the plant railroad lines as few times as possible in order to prevent accidental contacts with locomotive cranes, as this is a frequent source of accidents. In reaching transformer banks quite a few crossings may be eliminated by using lead cable underground for a short distance. Where crossings must be made the towers should be designed for liberal clearance.

Fig. 2—Arrangement of cables over power house.

As shown in the small diagram at the lower center of Fig. 1, the cables leaving this power house are carried on racks. This arrangement was necessary because the alley between the power house and the adjacent building is only 15 ft. wide and hence it was out of the question to start the steel towers at this point. The cables are carried on these racks for a distance of 200 ft. and then go to the pole line.



Series Lighting Circuits Should Be Handled as 6,000-Volt Lines

Series lighting circuits find favor for yard lighting in plants of large area and where no elements destructive to insulation are present. In general these circuits should be installed, insulated and handled as if they were 6,000-volt lines, for in case of a grounded circuit near the constant-current transformer a very high potential to ground will exist near the other end of the line. Inasmuch as this circuit is treated as a high-potential circuit it should obviously be installed just under the 2,200-volt lines, as shown in Fig. 5. In order to insure sufficient mechanical strength, the conductors for this circuit should be of solid conductor not smaller than No. 6 hard-drawn copper and should have triple-braid,

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weather-proof insulation. Splices may be made with a McIntire sleeve so as to give maximum strength in the joint and to prevent annealing of the wire by soldering.

The insulators should, as was the case with the 2,200-volt lines, be of porcelain and rated at not less than 6,600 volts. The conductor should be securely tied to the insulator with insulated wire not smaller than the line conductor. The series lighting circuit should be attached only to strictly electrical structures and should never be attached to pipe supporting towers or to buildings, for the possibility of high voltage on this circuit constitutes quite a hazard to workmen around such structures and also hampers fire-fighting operations. Where it is essential that lights operating on such a circuit be attached to buildings, a series transformer should be installed on the nearest tower and the secondary run to the light, thereby insulating the lamp from the circuit. Where a pole must be set for a light only, a lamp standard with underground parkway cable may be substituted and will present a more attractive appearance.

Layout of Clock, Fire Alarm, Signal and Code Call Circuits

The remaining general circuits to be considered are the clock, fire alarm, signal code call and telephone circuits.

The clock-regulating circuit as furnished by the telegraph companies consists of a single wire over which impulses at 250 volts are sent once an hour. These impulses regulate or set the clocks, which are arranged in multiple. The winding of the clocks is usually accomplished by a dry cell in the clock case. Many plants use a local master clock, however, which sends out an impulse once per minute and advances the clock hand by that interval, the source of energy being ordinarily taken from the lighting service or from storage batteries.

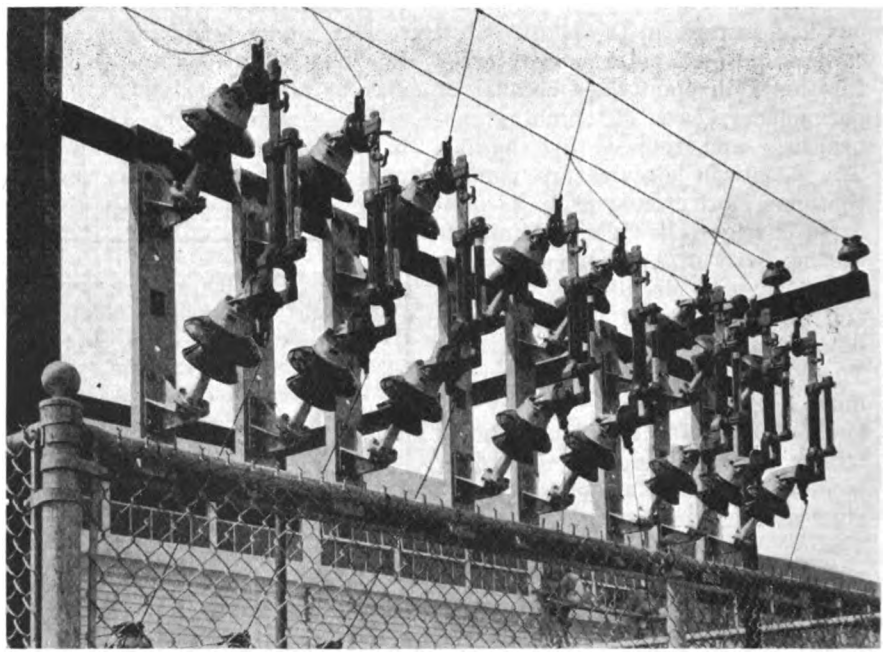


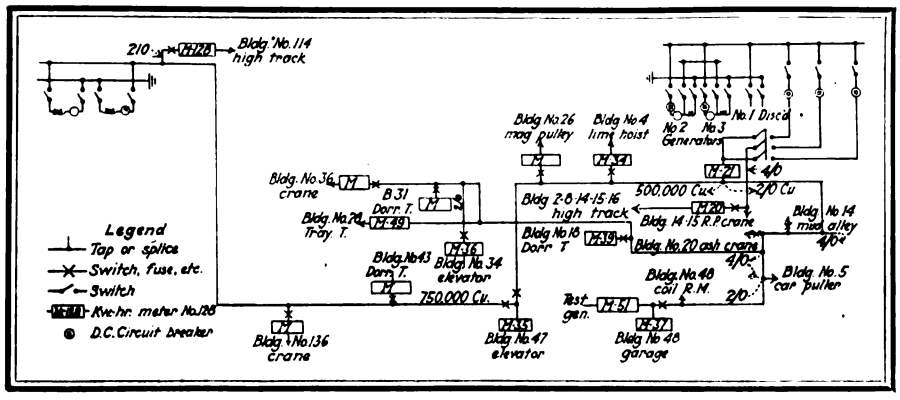
Fig. 3—In some plants line sectionalizing is desired without the use of air-break switches.

This may be accomplished through the use of a fused disconnecting switch. These disconnecting switches must not be opened under load. However, under no-load conditions they may be used to isolate sections of the line. The fuses are of the high-tension, chemical type, made by Schweitzer & Conrad, Inc.

The code call circuit is usually operated from the telephone operator's desk by some automatic, code-sounding device. This sends out 110-volt impulses to the vibrating horns, bells and whistles in the plant, which are connected in multiple. Owing to the small amount of energy required by the horns the lines may be as much as a mile long and operate several horns satisfactorily at this low voltage.

Fig. 4—This shows the direct-current circuits of the plant mentioned in Fig. 1.

These circuits are carried on the same poles as those shown in Fig. 1. The reason for showing them in a separate diagram is to make the diagram more simple and easy to follow in tracing the circuits.



The various other signal circuits will seldom require over 110 volts. The fire alarm circuits are usually of the closed-circuit type with a break-glass or pull-down box for giving the coded interruption to the closed circuit which is energized by a number of primary battery cells. The circuit may be energized by 250 volts d.c. or lower, through a resistor in order to give the required value of current for operating the relays. Quite often the alarm is sounded throughout the plant by single-stroke gongs, operated in series or in multiple on 250 volts d.c. These bells are located at strategic points in the yard and in all buildings.

The nature of the above circuits would indicate that they should be installed on the crossarms lowest on the tower, but above the smaller and mechanically weaker telephone wires, as is shown in Fig. 5. These circuits should never cross over 2,200-volt circuits and should be at least 4 ft. below such circuits because these signal circuits enter buildings and the connected apparatus is frequently within touch of a large number of people who should be safeguarded as much as possible. These circuits should use a line conductor not smaller than solid No. 8 hard or medium-hard drawn copper, covered with triple-braid, weather-proof insulation. The line insulators may be of glass, single-petticoat type. The conductors are tied to the insulators with insulated wire not smaller than the line conductor. Where these circuits leave the tower or pole lines and run inside or outside of buildings, they should be enclosed in con-

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duit to prevent mechanical damage or electrical crosses with other wires.

The telephone circuits may be called the arteries of the plant and deserve careful consideration to prevent accidental interruption of service and to insure safety. To the writer the bare telephone line has never appeared to have any justification for use within the industrial plant yard. It is especially liable to accidental crosses with other circuits, it is easily broken, and when a break occurs it usually wraps about other circuits and shorts them out; also this method takes up a large amount of expensive pole and crossarm space. Where five or less telephone circuits must be run in the open for less than 300 ft., No. 17 s.c.c. rubber-covered, weatherproof braid, twisted-pair telephone wire may be profitably used. For longer distances or where a larger number of lines are required, service and safety are promoted by the use of lead-covered telephone cable. A sufficient number of extra pairs should be provided for the probable increase in traffic, which inevitably occurs.

In order to safeguard the delicate telephone equipment and protect the telephone user, a line protector consisting of a lightning arrester and fuses should be installed on each circuit where it enters a building.

The telephone lines inside of the building usually use No. 19 tinned-copper, twisted-pair conductor with rubber insulation and a single glazed braid.

Lead-covered telephone cable, where installed on the plant steel tower lines, requires some modifications of suspension practice to secure safety. In making a number of investigations of cable troubles ascribed to lightning the writer found small holes burned in the cable under the supporting clips, often as many as 17 holes would be found in a length between three towers. While being familiar with the vagaries of lightning the casual explanation did not appear logical and so the insulators of the 2,200-volt lines on the adjacent towers were given a minute examination. In three cases there were found defective insulators which had a crack extending either from the top of the saddle or from the tie wire groove to the iron pin. During a storm a heavy current would pass from the cable through the cracked insulator and thence to the pin through the tower to the messenger cable. The current would go both ways to the adjacent towers. Inasmuch as the messenger wire was in parallel with the lead sheath, current would enter the lead sheath through the supporting rings, thereby burning small holes in the lead sheath. In one instance the switchboard operator observed a heavy surge on the 2,200-volt feeder on which the trouble occurred. Although all of the towers were well grounded, the RI drop in the steel tower forced the current along the messenger and lead cable to the adjacent towers.

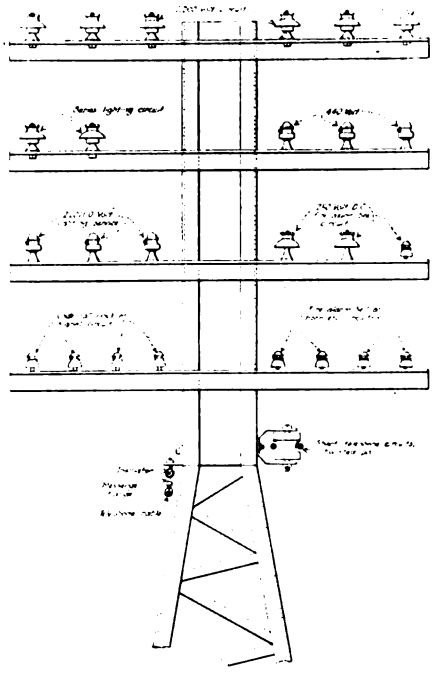


Fig. 5—Preferred crossarm locations for the different circuits of an industrial plant distribution system.

The high-voltage lines are placed on the uppermost crossarms. The lowest crossarms carry the various signal circuits, which are of low voltage. The alternating-current low potential and the direct-current low potential circuits are carried on the crossarms in between. Only four crossarms are shown here, but others can, of course, be added where needed.

Two methods have been used to eliminate this trouble, one being to mount a treated maple block on the tower and bolt the messenger clamp to it; the other is to put a horizontal angle on the tower and suspend the messenger clamp by a guy insulator from the angle extension, as shown in Fig. 5. Such isolation of the messenger and cable has been effective in eliminating these troubles. The messenger and cable are grounded at only one point, that being where they enter the building housing the exchange.

All telephone lines entering the plant cable from outside of the plant should be provided with an arrester and heat coils, as considerable damage may be caused by "sneak" currents burning open the lines in the cable.

Local Circuits Should Not Be Run on the Outside of Buildings

The motor circuits are usually of 440 and 550 volts a.c. and 250 volts d.c. Since they are local in character they seldom occupy much space on the yard towers. Where the low-

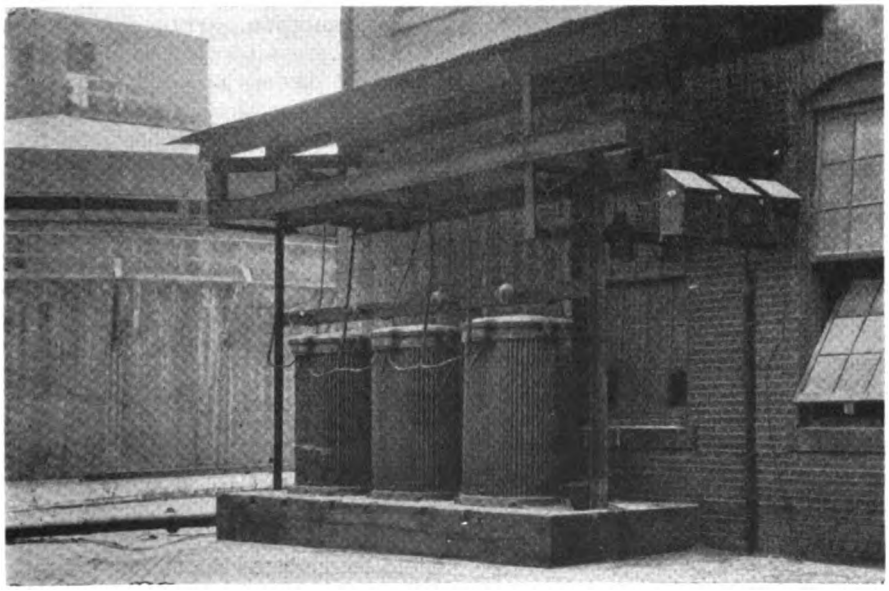


Fig. 6—Lead-sheath cable is used for connecting the transformer bank to the overhead line.

A cable pothead is installed at the top of the pole. The cable is run down the pole and underground to the transformer bank. For protection, the cable is run through conduit underground and for 10 ft. up the pole and at the transformer bank. The illustration shows the cable and conduit coming out of the ground at the bank of transformers. The cable terminates in a pothead which is located behind the lightning arrester at the right center of the illustration.

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tension circuits supply two or three buildings adjacent to a step-down transformer bank they may occupy the space on the tower below the 2,200-volt circuits and above the signal circuits, as is shown in Fig. 5. The design of these circuits should be such that they will not be run along the outside of the buildings being served, as they detract from the appearance of the building and in some cases may pull the framework of the building seriously out of line. To the writer's knowledge this has happened, and it really is very poor practice unless the design of the building is positively known to be able to stand the strain of the wires under all conditions. There is also considerable danger in connection with firefighting operations around the building, if power circuits are run on the outside.

The service entrance may be by means of cables stretched from the tower line to the building with a conduit entrance into the building. Main switches should be provided inside of the building, so as to make it possible to shut off power to the various parts of the building. The most common fault of these service connections is that the cables are not spaced far enough apart and insufficient clearance from grounded structures is provided. Under such conditions short-circuits are easily established and changes in sag and alignment cause grounded circuits. Where space on the tower is crowded it may be advisable to use lead-covered, three-conductor power cables with potheads and run such circuits down the tower and underground into the buildings.

The installation of 2,200-volt lighting transformers on the yard towers always presents a problem both in securing clearance for the primary leads and safety to the repairman working on a case of trouble. A very satisfactory solution is to eliminate the 2,200-volt transformer on the pole or tower and install a 440/220/110-volt transformer at each 2,200/440-volt transformer bank. The lighting service may be supplied to the local load center from this point. The slightly increased losses are compensated for by the increased safety to linemen and greater security from lightning. The location of the 220/110-volt lighting circuit on the crossarms is shown in Fig. 5. Wherever transformers of any type are installed on the 2,200-volt system, the concensus of opinion favors the installation of lightning arresters.

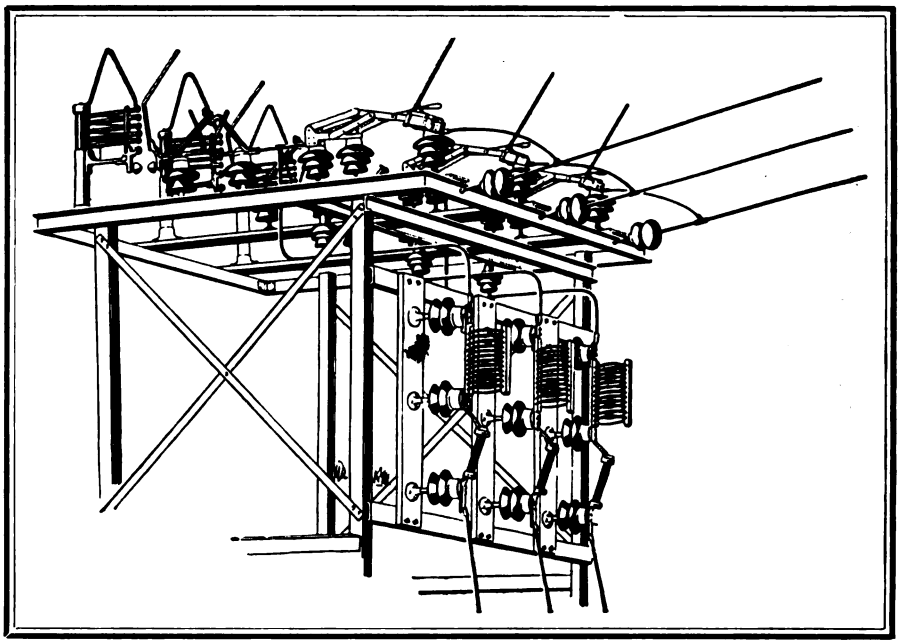


Fig. 7—Here is a typical layout for pole-top, air-break switches including overload protection.
The overload protection is obtained through the use of Schweitzer and Conrad high-tension chemical fuses. As may be seen, lightning arresters and choke coils are also provided for in this layout.

Quite frequently the industrial plant fails to observe the code ruling that the low-tension secondaries (110-220 volts) of transformers must be grounded, either on the neutral of the three-wire system or on one line wire of the 110-volt service. This neglect presents a certain hazard to men using portable electric drills, extension lamps, etc., and more serious results may occur in case of a breakdown of the insulation between the 2,200-volt primary winding and the secondary winding of a transformer.

Where the series lighting circuit is not practicable because of insulation troubles the yard lighting system may be operated in small groups from the 220/110-volt service just described. A satisfactory method is to mount a switch under each light and use an enclosed cutout between the main feed circuit on the tower line and the lamp. A weatherproof condulet push-type switch may be used in preference to a rotary switch, as the rotary switch buttons are often removed and lost by mischievous persons.

The 250-volt d.c. power circuit is frequently used for local service, principally for power house, machine shop and other variable-speed drives and traction service. Where the plant is large, several motor-generator sets will probably be used and relatively short feed lines employed. Considerable study should be devoted to the problem of eliminating drives requiring such special service at scattered points in the plant. These circuits should occupy about the same position on the poles or towers as the local 440-volt and the lighting circuits, as is shown in Fig. 5.

Considerable difficulty has been experienced from lightning disturbances on the 250-volt d.c. circuits and provision should be made for the use of lightning arresters at all building entrances. The only explanation offered by the writer's experience is that the a.c. circuits were always equipped with lightning arresters as a matter of course, while the d.c. circuits were not, until equipment losses indicated the necessity of this protection.

A plan of the distribution system is invaluable for the large as well as the small plant. On it should be noted the size of cable used, character of insulation, arrangement on towers, where oil switches and disconnecting devices are located, location of meters, capacities of transformers, and main secondary subdivision of lines. These constitute some of the important information easily forgotten unless noted on some form of drawing. Fig. 1 is a one-line diagram of the 2,200-volt and 440-volt lines in a large plant and on it is incorporated all of the information just mentioned. Fig. 4 is a similar diagram for the 250-volt d.c. system. Additions and revisions to these drawings should be made at regular intervals and new blueprints issued to those interested. Occasionally a new tracing should be made, as the old one wears out under many erasures.

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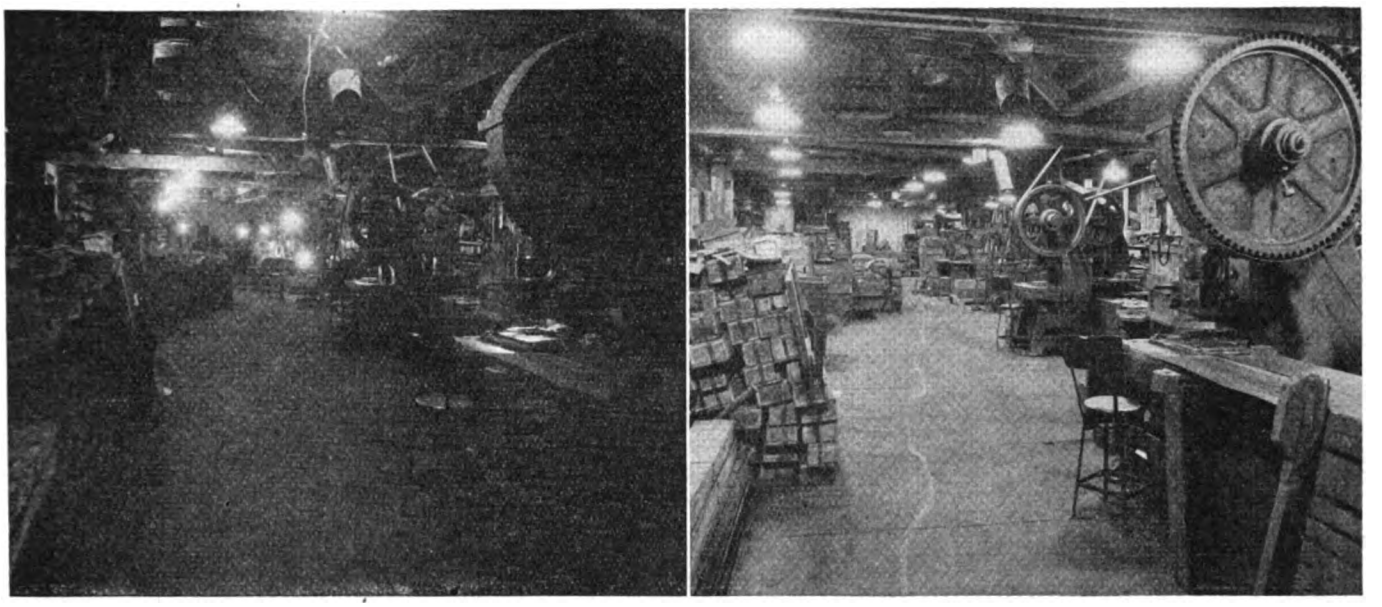


Fig. 1—**A properly-designed lighting system makes all of the difference between a dark and gloomy shop and one that is cheerful looking and easy to work in.**

The illustration at the left shows how the punch press department in one plant looked when illuminated by the original lighting system, which gave an average illumination of 0.7 foot-candles. As will be noted, drop lights had to be used at some of the machines. The other view shows the same department lighted by the new installation of 200-watt lamps in R L M dome reflectors. The new system gives an illumination of about 13.5 foot-candles.

Practical Pointers on

Better Illumination in Industrial Plants

Together With a Discussion of Results Obtained Therefrom in the Way of Increased Production and Reduced Accident Hazards

By ROY A. PALMER

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ARTIFICIAL light has become such an efficient and dependable asset in our modern life that we rarely stop to consider how much it contributes to our welfare and happiness. In almost every important activity in which we are engaged, artificial light plays some part and in the large majority of cases the role which it plays is almost indispensable.

Notwithstanding the rapid progress which artificial lighting has experienced and the completeness with which we have absorbed it into our daily lives, the lighting of this country as a whole has not reached a high standard. It is true that America can be termed the best-lighted country in the world, for other countries are far below even our present standard, but with the benefits which better lighting brings at a comparatively low cost there are possibilities for even greater use of light with profit to the user and worth while advantages all around.

There are, no doubt, many plant executives who feel that the lighting systems in their factories are fully adequate. However, the lighting systems which were satisfactory four or five years ago may be far below the standard of what is considered good lighting today. Changes in the structural features of the building have, perhaps, altered the existing arrangement of outlets, so that the illumination is now insufficient; substitution of improper lamps for those burned out or broken throughout the period of a few years may have introduced lighting conditions that are condemned by modern standards; or the character of the work now performed in the factory may demand a higher standard of illumination. These are only a few of the factors which require checking over to ascertain whether or not the factory is obtaining full benefit of the advantages which better lighting brings. In not a few cases have the lighting systems never measured up to good lighting requirements, and in those factories the matter of revamping the existing installation should be given the most serious consideration.

It is obvious that by the amount of light available we are accordingly enabled to see. During the hours of darkness we can only distinguish outlines of objects, but in the sunlight it is easy to perceive small details. That illustrates the wide range of intensity of light to which our eyes can adapt themselves. If a

WE ARE SO USED to doing a large part of our work by artificial illumination that it is easy to take such lighting for granted, without much thought as to whether the amount of light furnished, or the type of equipment used, are suited to the working conditions. Oftentimes, too, there is a failure to realize that a level of illumination that is entirely suitable for one class of work or conditions may be altogether inadequate for another kind of work or set of conditions. In this article Mr. Palmer points out the dollars-and-cents value of good lighting from the standpoints of production, decreased accident hazards and general improvement in working conditions. Other phases of this subject will be presented in articles which will appear in succeeding issues of Industrial Engineer.

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factory were operated only during the hours of darkness and no artificial light were provided, the output of that factory would be very small indeed. If only a little light were supplied, the output would be a little greater. The production would be almost entirely dependent upon the illumination supplied. While there are other factors which affect production, it can be readily appreciated how intimately good lighting is linked with production when we compare utter darkness and only a very small amount of light. But the efficiency of the worker is not at a maximum when the illumination is merely sufficient for good vision. The worker can see sufficiently well to work slowly under one foot-candle of illumination. Yet that worker is laboring under a partial blindfold. With five foot-candles of illumination that blindfold will be very considerably removed. At ten foot-candles the worker's visual powers have further increased. The finer the grade of work and the greater the demands upon the vision, the more light will be required.

The percentage of gain in visual power of the eyes is illustrated in the chart shown in Fig. 2. The curves show the results of tests conducted by Drs. Feree and Rand at Bryn Mawr University. In their experiments they found that as more light was supplied, the visual powers of a normal eye increased very considerably. With sub-normal eyes, however, it was found that their visual powers increased even more rapidly than in the case of normal eyes, when the amount of light was increased.

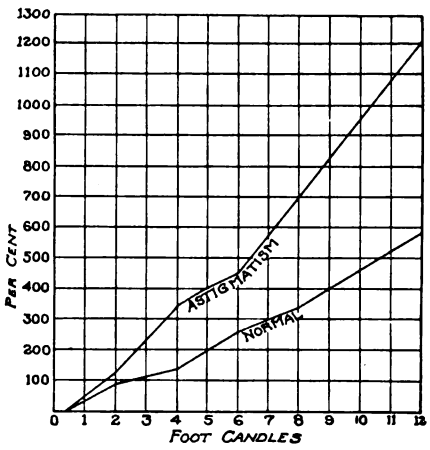


Fig. 2—How visual power increases with increase in the intensity of illumination.

This chart is based on the results of experiments conducted by Drs. Feree and Rand of Bryn Mawr University. It will be noted that the increase of vision with the increase of illumination is materially greater in the case of persons with defective eyesight than with those of normal vision.

Good Factory Lighting Improves Working Conditions

While the factory management is naturally most interested in those items which affect increased production or lower unit costs, more favorable working conditions are also important, for it is generally appreciated that the working conditions are reflected in the rate and quality of production. Good lighting is one of the greatest contributors to better working conditions. Inadequate lighting causes an atmosphere of gloom in the room. It is only fair to the workman that he be given a cheerful place in which to work, for it must be remembered that he spends at least one-third of his time at the factory. It is essential that the worker be provided with good tools and up-to-date machinery to turn out the best work. It is likewise essential that good lighting be provided so that his visual powers will enable him to use the tools and machinery to the best advantage.

There are many plants where the illumination is not what it should be, merely because of neglect of the lighting system. Changes may have been made in the factory at various times of the year, which perhaps cut off the light from some lighting units or in some other way rendered the existing lighting system ineffective. Perhaps more exacting demands require closer visual application and the level of illumination should have been raised to prevent unnecessary eye strain. Many other reasons could be cited why attention should have been given to the lighting system in order to assure adequate illumination. In view of the benefits which better lighting brings to the employees and the factory owners, it is important that every plant executive give due consideration to the lighting of his plant.

It is not an unreasonable claim that better lighting reduces accidents. There are many cases in which improper and inadequate illumination can be blamed for accidents and perhaps many more cases where the illumination may not be a direct, but is a contributing cause. Because of the fact that it is sometimes extremely difficult to determine the exact cause for some accidents, definite figures which show the direct relationship between accidents and lighting are not readily available. However, one does not need to stretch the imagination to realize the possibility of accident in a poorly lighted factory. Stairways, objects hidden by dark shadows, swiftly moving machine parts are only a few of the sources of accident when insufficient or improper light prevents the sense of sight from acting quickly enough to avoid danger. Examples of these conditions are shown at the left in Figs. 1 and 3.

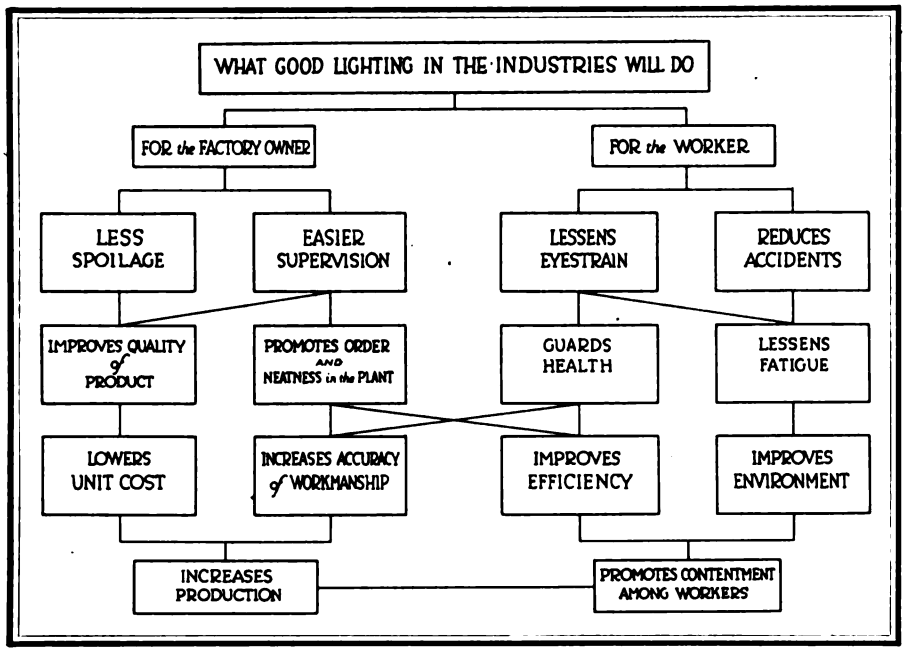
In direct contrast to light and accidents, definite and tangible figures are available regarding the effect of better lighting on production. Many tests which show the important bearing of light upon the output of the plant have been made in various industries. Illumination production tests have been made in industrial plants covering a wide variety of operations. The results of nine such tests are shown in the accompanying table.

One of the most interesting of these tests was that conducted by the Office of Industrial Hygiene of the United States Public Health Service. In the belief that the work of letter sorting could be expedited by supplying more light upon the

Results of Some Tests That Show the Practical Value of Good Lighting

Kind of Work	Average Foot Candles with Old System	Average Foot Candles with New System	Per Cent Increase in Production, New System	Additional Lighting Cost in Per Cent of Payroll
Pulley finishing	0.2	4.8	35	5
Soft metal bearings	4.6	12.7	15	1.2
Heavy steel machine	3.0	11.5	10	1.2
Carburetor assembly	2.1	12.3	12	0.9
Manufacture of electric, gas and sad irons	0.7 (4.0 at tool point)	13.5	12.2	2.5
Semi-automatic buffing brass shell sockets	3.8	11.4	8.5	1.86
Manufacture of piston rings	1.2	18.0	25.8	2.
Letter separating	3.6	8.0	4.4	0.6
Inspecting roller bearing parts	5.0	20.0	12.5	2.4
Average	2.69	12.47	15.04	1.96

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work, this test was undertaken. The illumination was raised from 3.6 foot-candles to 8 foot-candles and it was found that the speed in the work of letter sorting was increased 4.4 per cent. Since the work in other departments of the post office is mainly visual, it is reasonable to believe that a similar increase would obtain if the level of illumination were raised. It was estimated that a saving of $109,000 could be made in the post office where the test was conducted, should the same increase of speed apply throughout the entire office. The economy of better lighting is even more striking when the fact is taken into consideration that this saving is three times the increased cost of illumination.

Another interesting test was conducted at the Timken Roller Bearing Co. plant at Columbus, Ohio. Several weeks were devoted to this test and the high and low levels of illumination alternated weekly. The test was conducted in the inspection department where thousands of bearings are inspected. This process requires fairly close visual application. The effect of better lighting was brought out in a striking manner by the production figures under the low and high levels of illumination. When the high level of illumination was provided, the production increased; when the illumination was cut down, the production decreased. With each change in the level of illumination the production output responded accordingly. The illumination in this plant was originally five foot-candles, which is not so low as is found in many plants. The new lighting system installed for the test provided 20 foot-candles. While the five foot-candles of illumination were sufficient for fairly good vision, the new installation helped the speed of vision and produced a stimulating atmosphere in the plant so that production was increased 12.5 per cent.

The average increase in production for the nine tests, as shown in the table, is 15.04 per cent, with an average additional lighting cost of 1.96 per cent of the payroll. Increases in production as high as 25.8 and even 35 per cent were obtained in some plants.

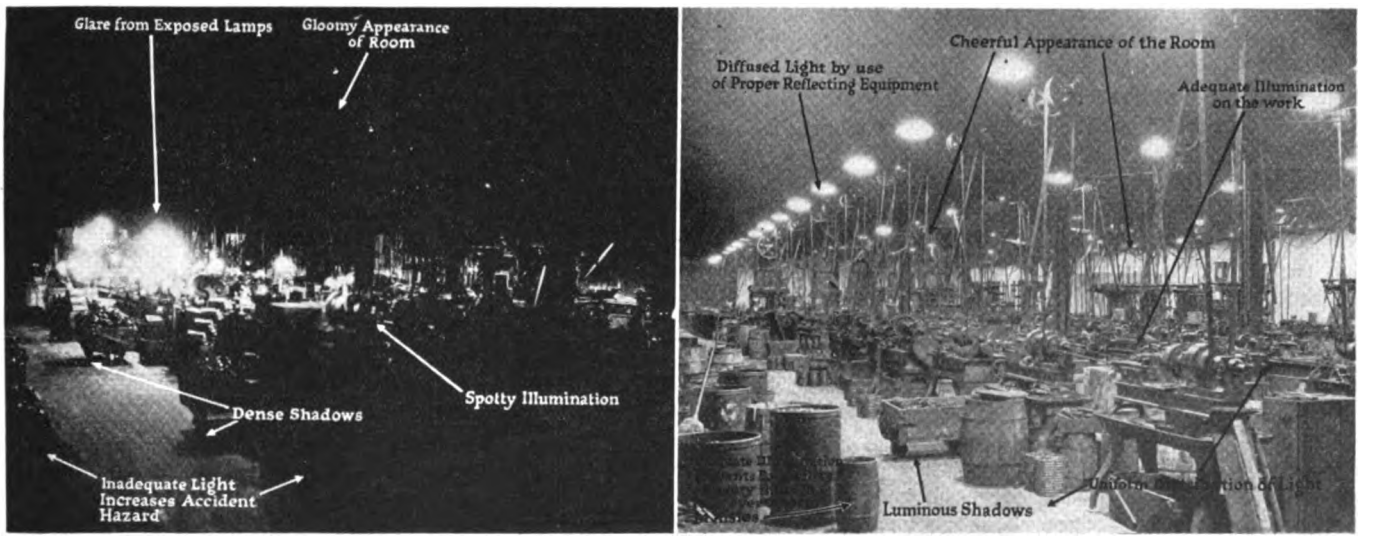
In each one of these tests every effort was made to balance out all factors that could affect production figures, except lighting. Furthermore the tests were conducted over a period sufficiently long to obtain average conditions and results.

If it were only possible for every factory manager to view his plant as it would appear if illuminated by an up-to-date lighting system, there would be no need to try to convince him of the benefits of better lighting by means of statistics. The immense contrast in the appearance of the rooms, the ease with which small details may be seen, and the stimulating effect of an abundance of light would be sufficient for him to realize that more and better work could be done under such conditions. It is somewhat difficult to appreciate

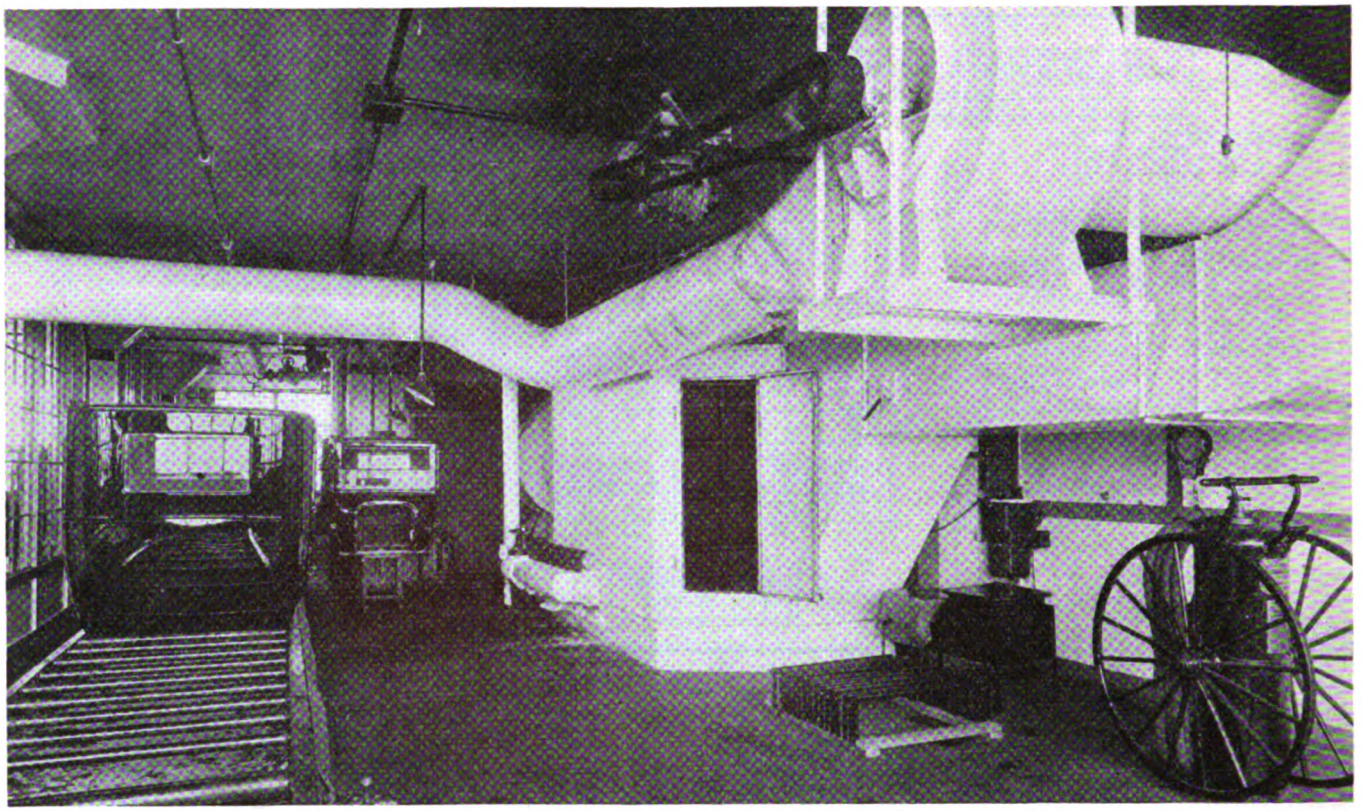
(*Please turn to page 402*)

Fig. 3—These illustrations show some of the points of difference between poor and good lighting systems.

As will be seen in the photograph at left, the use of localized lighting at some of the machines, results in a very low level of illumination (0.2 foot-candle) throughout the remainder of the room. In particular, the very poor lighting of the floor around the machines and in corners constitutes a serious accident hazard. In contrast, the view at right shows how all of these objectionable features can be eliminated by a lighting system that is properly designed and adequate for the service. In this illustration, the illumination is about nine foot-candles.



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Here a number of sectional filter units are used to purify the air used in the drying room in an automobile plant. The sectional units may be seen through the open door leading into the heater room.

Some Things It Pays To Know About

Separating Dust from Air in Industrial Plants

So That Clean Air May Be Used in Industrial Processes, for Heating and Ventilating, or May Be Discharged into the Atmosphere

By CHARLES L. HUBBARD

Mechanical Engineer, Boston, Mass.

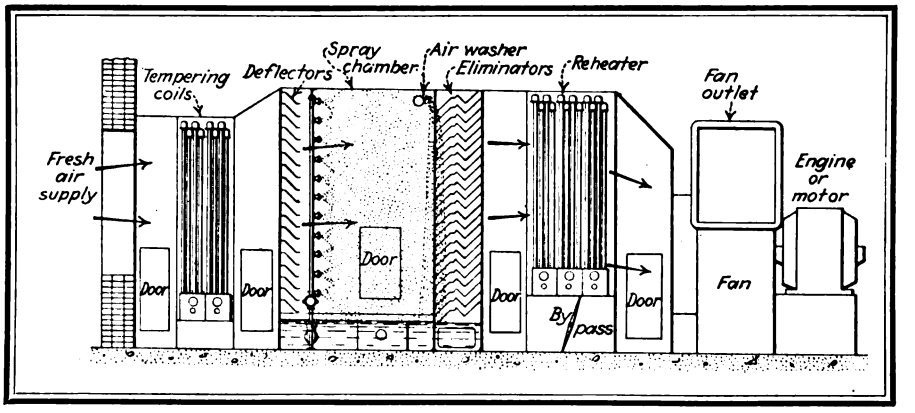
AFTER dust has been removed from the atmosphere or collected from exposed surfaces upon which it has settled, as was described in the preceding article entitled, "Removing Dust Produced in Industrial Plants," in the July issue of INDUSTRIAL ENGINEER, it must be separated from the air which carries it before the air can be exhausted into the plant or the atmosphere. In other cases the atmospheric dust in incoming air must be removed before the air can be used in and around the processes performed within the plant. Some of the methods of doing this will be taken up in this article.

Dust-laden air is cleaned by passing it through some type of separator. In general, these separators are either of the "wet" or "dry" types, although in some cases both types are used together. Generally, if the practically dust-free air is to be discharged into the open some form of dry-type separator is used. It is seldom necessary to have the discharged air absolutely dust free, as it usually can contain some fine particles which become diffused in the atmosphere.

ATMOSPHERIC DUST must be removed from incoming air before it can be used in many processes. Also, the dust-laden air, which is taken up in industrial sweeping operations and other methods of dust removal, as was described in the July issue, must be cleaned before it can be discharged into the atmosphere. Some of the various types of equipment used for removing dust from air are taken up in this article.

When the dust and dirt are collected by pneumatic sweeping equipment it is practically always necessary to remove them from the air before passing through the exhauster, as was explained in the previous article. This is because most types of pneumatic sweeping equipment use either rotary or multistage turbine exhausters which do not pass solid material. Where a quantity of solid materials is picked up in a sweeping process, such as when sweeping floors in boiler rooms and in grain elevators, the air is often passed first through screens or through a centrifugal separator which removes all large pieces and then through a bag or other similar filter to remove the dust. For ordinary sweeping work so few large, solid particles are gathered up that a separate centrifugal separator is seldom necessary. A separator which employs the centrifugal principle for the removal of the coarser particles and a filter bag for removing the

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This diagram shows an air washing unit in connection with a heating system.

Here the incoming air passes through a spray chamber filled with mist and then through a heavier curtain of water which drives the particles of dust, already moistened by the mist, down into the settling chamber. Moisture is largely removed in the eliminator.

finer dust is shown in a sketch on page 369.

With dry separators, whether of the centrifugal, screen or bag type, the dirt accumulates in a closed chamber at the bottom of the separator and must be removed at frequent intervals for burning or other disposal. In some cases the dust chambers are emptied automatically, as was shown in the illustration at the bottom of page 322 in the July issue. Here, as the dust accumulates, the dust pan automatically trips and empties itself without interfering with the operation of the separator.

In some cases screw conveyors or other devices in continuous operation are used to remove the dust deposited in the bottom of filter chambers. In many cases, however, particularly where a small amount of material is recovered from the air, hand valves or gates in the bottom of the settling chamber are sufficient.

The cleaning of the filter cloths is a still more important item. In some cases these bags are cleaned regularly by shaking or rapping. This is sometimes done by a revolving shaft and a cam action which regularly jars the material loose from the bag. In other cases the equipment is stopped at intervals and the direction of the air current reversed, which causes the material to drop loose from the inside of the bag. With filter equipment where it is necessary to reverse the air current to clean the bags, an installation is usually made up of several units so that one unit can be cut out at a time to be cleaned. The length of time between cleaning depends, of course, upon the material handled and the quantity of dust removed.

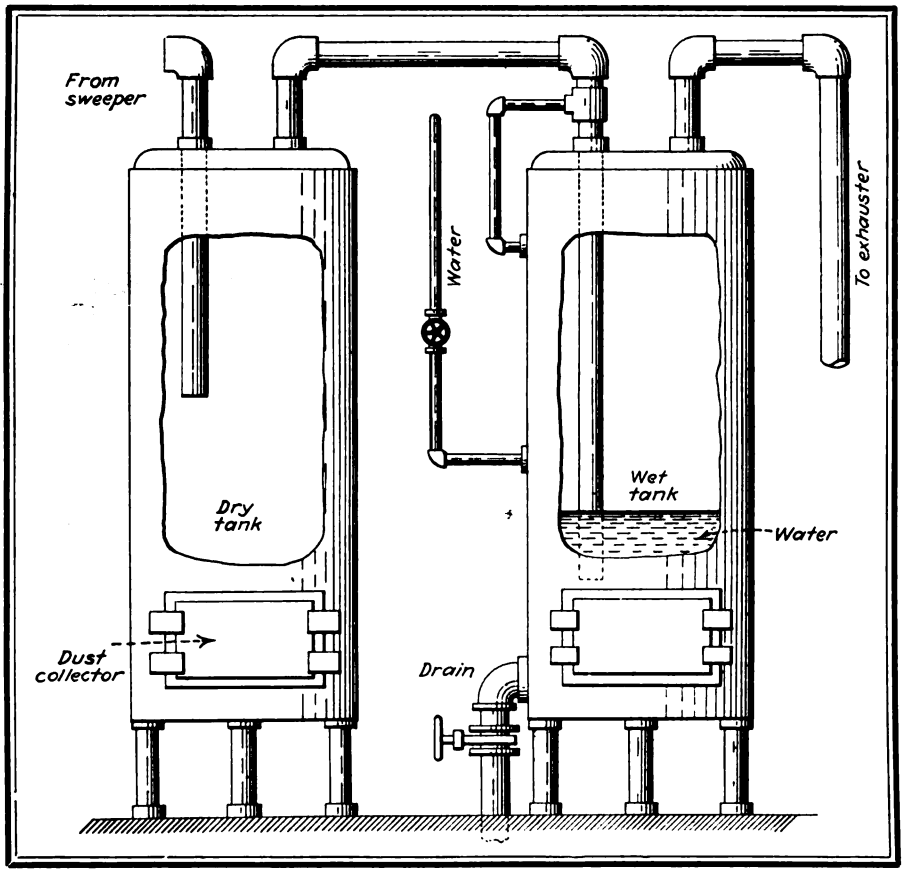
Keeping the bags clean is an important part of the operation of a bag filter, and demands close attention. If the dust is allowed to accumulate to too great a depth on the inside of the bag, the resistance to the passage of the air is materially increased, which increases the power required to operate the system.

It is hardly to be expected that any one set of filter cloths or bags could be used for handling a variety of dusts. Even in the same industry different cloths are required for various steps or processes. Also, special precautions must be taken to prevent fire. Metal screens are commonly used to filter hot mixtures.

Where it is immaterial, or is desired, that moisture be added to the air, wet filters are frequently used. This is especially true when recirculating heated air in a building. In a wet filter, air passes through a mist or curtain of water in an air chamber and has all foreign particles washed out. In addition, it picks up moisture which is a desirable and necessary element in a hot air heating system. Recirculated air is sometimes treated with ozone to revitalize it.

In wet separators the dust-laden air is passed through water before it is exhausted. This washes out the dust and exhausts clean, moist air. This is ordinarily not done unless the air is to be used again, such as for recirculating in heating and ventilating systems or for use in processes, because a small amount of dust in the exhaust is seldom considered harmful. The dust settles to the bottom of the water chamber and is flushed out either into the sewer or into a settling tank. Seldom is such dust of any value.

One of the important parts of all



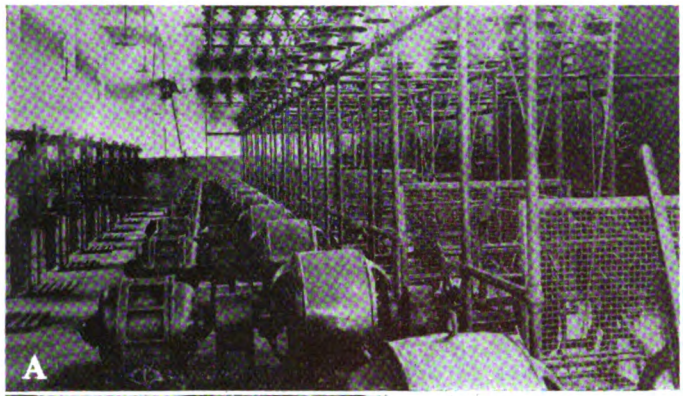
In this case dry tanks and wet tanks are both used.

Equipment of this sort is frequently used in connection with pneumatic sweepers. The first tank removes all the heavy solid materials and most of the dust. Any dust carried over in the air is separated by passing through the water in the second tank.

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Equipment for Separating Dust from Air

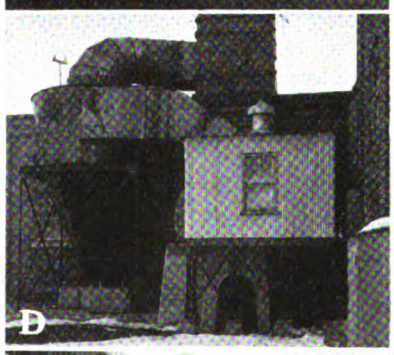
Ten Examples of Applications in Industrial Plants











A—This shows a portion of an installation of 24, 10-kva., 75,000-volt, General Electric generator sets, transformers and switchboards which supply high-voltage current for a Cottrell precipitation service.

B—These bags hold five days' catch of dust obtained in a Cottrell precipitator at the plant of the Riverside Portland Cement Co.

C—This battery of four compound centrifugal separators recovers about 40 tons daily of kiln dust in a cement mill.

D—Here the outlet from the cyclone separator discharges into a stack instead of into the open air.

E—In this installation the dust-laden air passes through a series of screens. Dust deposited on these screens is loosened at frequent intervals by jarring and is removed from the hopper at the bottom.

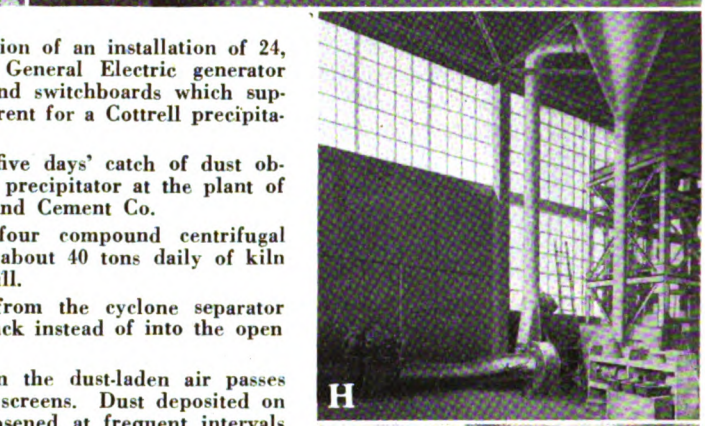
F—This bank of sectional unit filters is installed on the inlet to a ventilating system.

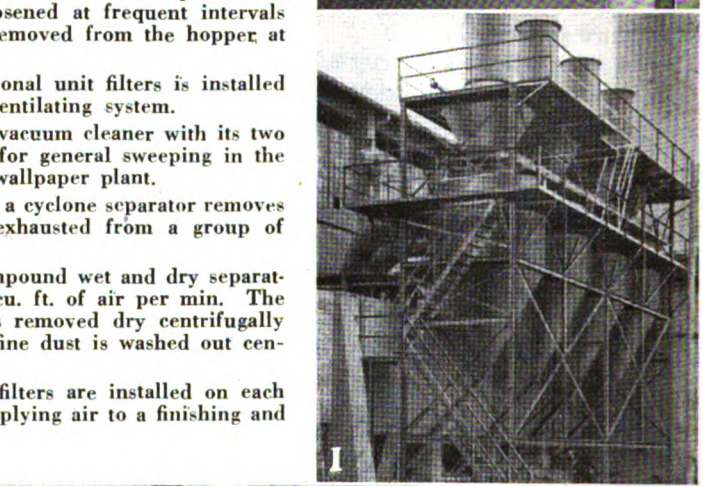
G—Here a stationary vacuum cleaner with its two filter tanks is used for general sweeping in the coating room of a wallpaper plant.

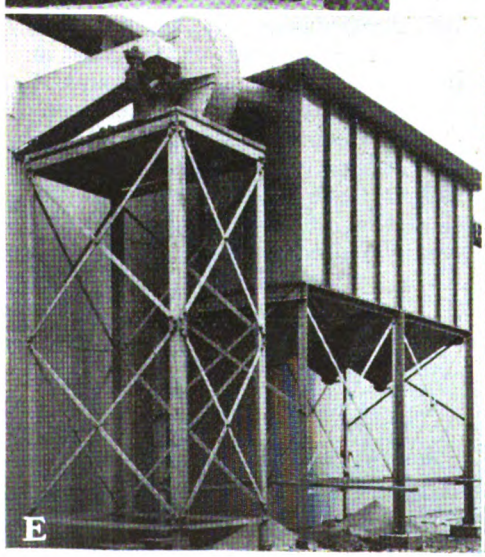
H—In this installation a cyclone separator removes the grinding dust exhausted from a group of emery wheels.

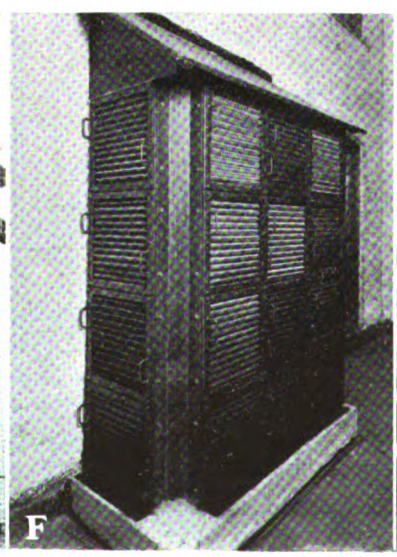
I—This battery of compound wet and dry separators handles 80,000 cu. ft. of air per min. The bulk of the dust is removed dry centrifugally and the remaining fine dust is washed out centrifugally.

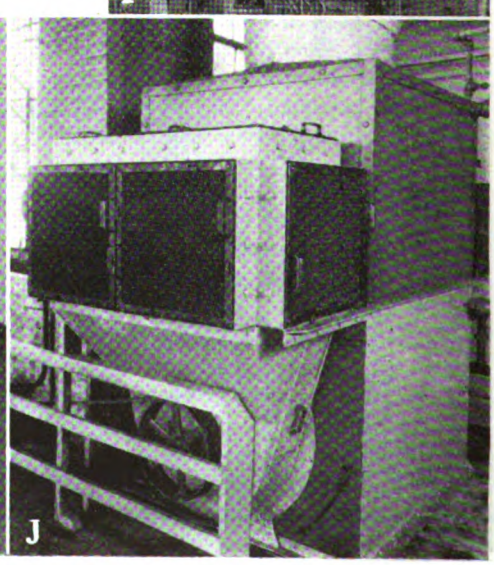
J—Six sectional unit filters are installed on each side of a heater supplying air to a finishing and drying room.



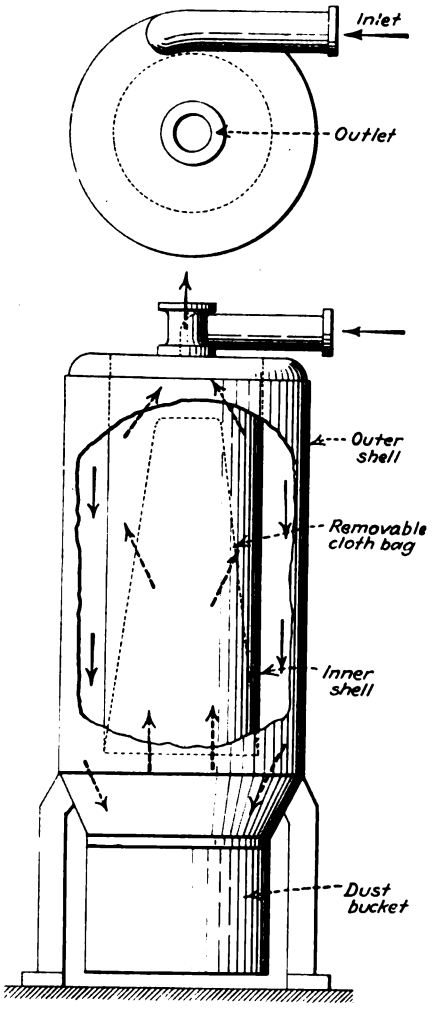








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This is one type of combination centrifugal and bag filter.

The dust-laden air enters the centrifugal separator at the top and loses practically all solid material as well as much of the dust in its passage around the circumference of the separator between the outer and inner shells. The dust and heavy material fall into the dust bucket. Any fine dust remaining in the air rises upward and is removed as the air passes through the removable cloth bag.

wet air filters is an adequate settling tank, if the water is to be recirculated. Another point which is often neglected is seeing that wet filters are of substantial construction.

Frequently the wet and dry systems are combined. The heavier dusts are removed by the dry process and the fine dust washed out as described. An outfit for this purpose in which the dry tank, at the left, operates by changing the direction of the air current, is shown in the sketch on page 367.

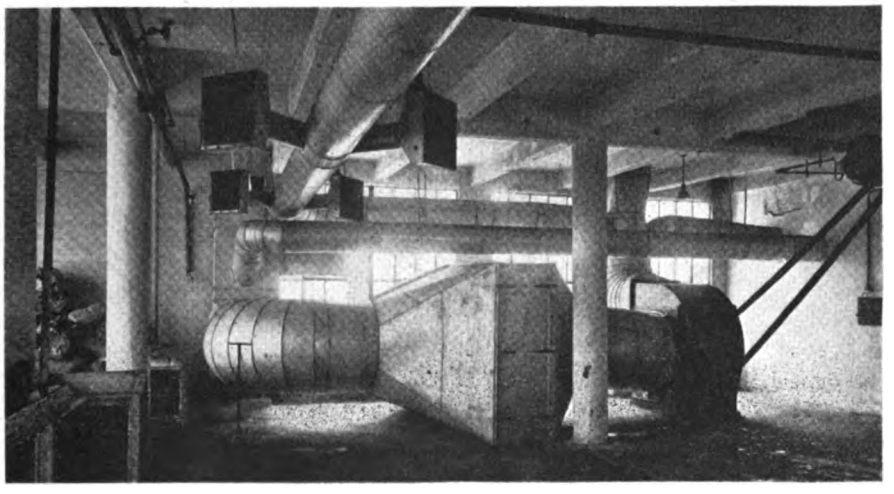
There is a large variety of types of wet and dry filters. Many of the dry filters are made of cloth and differ largely in the arrangement of the cloth, either in the form of screens or bags, and in the provision for cleaning and emptying. In any case it must be remembered that cloth or other filters should not be forced too much, or the increased pressure or vacuum will drive particles through the filter. The remedy is to increase the surface area of the filters. Whenever an installation is planned, it is well to take up all details of the operating conditions with the manufacturer, and particularly to consider the maximum capacity which the filter will be called upon to deliver at any time.

Some of the more common industrial operations which require clean, filtered air are in connection with the cooling of machinery in operation or the air used in a machine, such as on turbo-generators, motors, air compressors, pneumatic tools, air brakes, gas engines, etc., Filtered air protects the equipment from accumulations of dust and from undue wear. Also, it is frequently necessary to use dust-free air in the manufacture of certain products, such as food products, fine chemicals, photographic plates and films, some textile fabrics and in other processes. Either wet or dry systems are commonly used in connection with ventilating equipment for offices and factories, as they not only remove the dust but many germs. In some industries, such as food product plants, it is frequently necessary to have air practically free from bacteria.

One of the big problems in industrial plants is in connection with the operation of turbo-generators and large motors, particularly in steel mills. In these cases it is frequently necessary to use forced circulation of air through the equipment to help keep it cool. Unless the air is clean, dust accumulates on the windings. For this reason the air surrounding the equipment could hardly be used without some treatment. In one steel mill, for example, two large fans delivering 90,000 cu. ft. of air per min. force incoming air through an air washer for cooling and cleaning before supplying it to two large reversing mill motors and motor generator sets, in addition to seven smaller auxiliary mill motors out in the plant. In another case the main motors and generator sets are installed in a special room which is kept under a slight pressure, just about that of the atmosphere, so that no atmospheric dust can enter. Cleaned air is forced into this room as well as through the machines, to keep them cool.

In addition to the types of wet filters already described, there is other special equipment commonly known as scrubbers. While these were originally designed for use in connection with removing dust and particles from hot gases, they are frequently used in many other applications for dust removal.

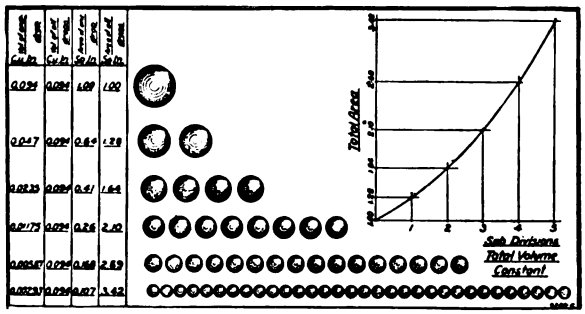
One type of these is a combination centrifugal wet scrubber. In this the incoming gas is passed through a revolving disk with a large number of pins projecting outward at an angle and staggered. This disk is rotated at high speed and water, oil or other liquid flows down and over the wheel. The high speed forces the liquid out through and around the projecting pins. The gas passes through this and up around the outer shell and into the outlet. The high speed of rotation, it is claimed, forces the particles of dust into the



In some food products plants bacteria which are carried on dust must be removed.

Here the air discharged into the room is first passed through special filters, the large square objects at the end of the short extension from the pipe at the ceiling. In this way the dust is removed along with any bacteria it may be carrying just before the air enters the room. This installation is in a gelatin factory.

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How fineness of mist affects wet washing.
In wet washers a fine mist will present more wet surface to catch the dust, than if the drops are heavier. This table shows the relation of the surface area of various sizes of water particles where the volume of each group of particles is the same. For this reason the fineness of the mist as well as its density is important.

liquid which flows down through the settling chamber and out. Oil is used where it is not desired to increase the humidity and certain chemical solutions are used where it is desired to absorb certain elements out of the gas. It is claimed that with the use of oil practically 100 per cent of the dust may be removed. In starch mills, for example, the starch water is recirculated until it gets heavy with starch. It is then drawn off and reprocessed, thus saving what formerly went to waste.

Electrical Precipitation of Dust or Fumes from Air

There is still another method of removing dust and fumes from air or smoke before it is discharged into the atmosphere. This is known as the Cottrell electrical precipitation process and was originally developed for use in settling acid mist, created in the manufacture of acid, so that it would not be discharged into the atmosphere. In addition to the wide use of this process in depositing vapors created in chemical processes, it is also widely used in removing solid materials, such as dust, from air and fumes.

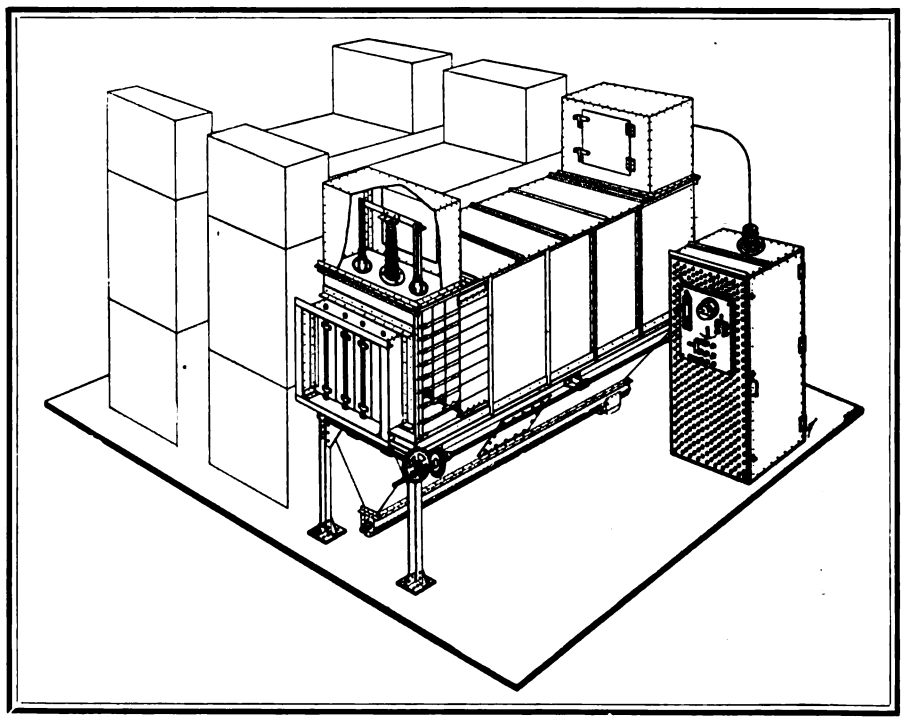
The electrical precipitation of dust consists in passing dust-laden air or gas between two oppositely-charged elements, one being a wire known as the "discharge electrode" and the other a plate or "collecting electrode." With proper conditions of electrical potential and velocity of the air or gas, the dust will be precipitated on the collecting electrode, and the air or gas will pass through unaffected. The precipitation apparatus consists of a number of wire electrodes and plates, together with the electrical equipment to produce the high potential discharge required. The electrical equipment consists of a small switchboard, a synchronous motor and mechanical rectifier, and a transformer; these produce a unidirectional current at an operating voltage of 30,000 volts or more. The potential is maintained on the precipitator or collector at a voltage at which there is a "corona" or silent electrical discharge from the wire to plate and below the point where there would be a disruptive or arc discharge between the wire and plate.

This equipment is built in units so that at intervals, determined by the amount of dust collected on the plate, the power and the flow of air may be cut off from one unit automatically and the plate cleaned by mechanically jarring or vibrating the electrode. The dust or other material falls into hoppers and is drawn off as desired by screw conveyors or other means. The automatic damper control, power switching and electrode cleaning devices are interlocked and synchronized.

Where the problem involves elimination of a dust nuisance the efficiency of operation is so adjusted that the nuisance will be reduced to a minimum consistent with economy of operation.

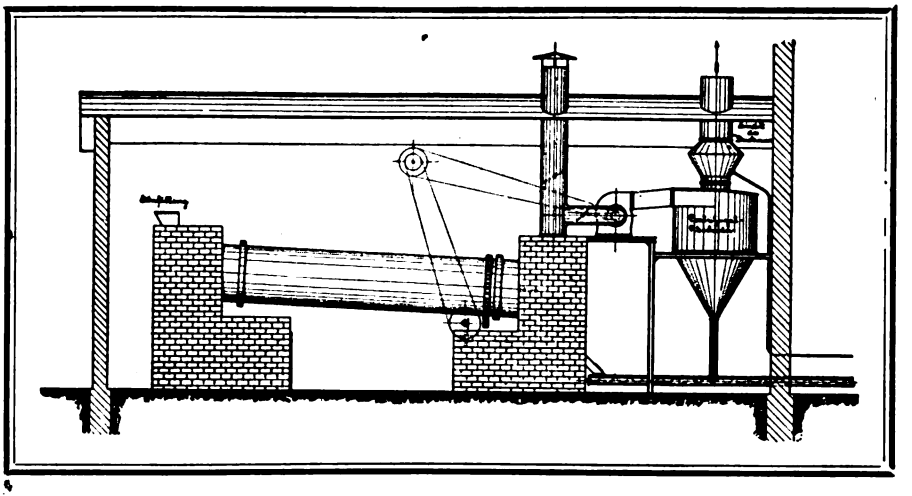
For some work standardized units may be used. One of these is shown in an illustration on this page. The capacity of the units depends upon the efficiency of removal desired. When operated at 90 per cent efficiency, for example, a much larger quantity of air may be handled than if 99 per cent efficiency is desired. For larger volumes additional units may be added either in series, in parallel, or in series-parellel. Electrical power consumption of two such standard units is approximately 1.5 kw. But little attention need be given to this equipment, other than occasional inspection of the electrical equipment and periodical cleaning and attention to the precipitator. There is very little wear on the precipitator parts from the abrasive action of fine dust. For this reason, the depreciation on the equipment as a whole is small. Also, but little back pressure, and that is uniform, is created by this apparatus.

The efficiency is independent of the dust content of the gases. If the air or gas contains constituents which are corrosive, special materials can be used in the construction of the equipment. Where food products are recovered, not only are special materials used, but provision is made to cleanse and sterilize the apparatus. Bacteria are destroyed by this process of removing dust and



One type of standard unit construction in the Cottrell electrical precipitation process.
As the dust-laden air passes through this equipment the dust is deposited on the "plate" electrode as described in the text. A high-potential, unidirectional current of approximately 30,000 to 50,000 volts causes this precipitation. The dust or other material is collected in hoppers at the bottom and drawn off by a screw conveyor.

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In this case combination wet and dry separators are used so that no dust escapes.

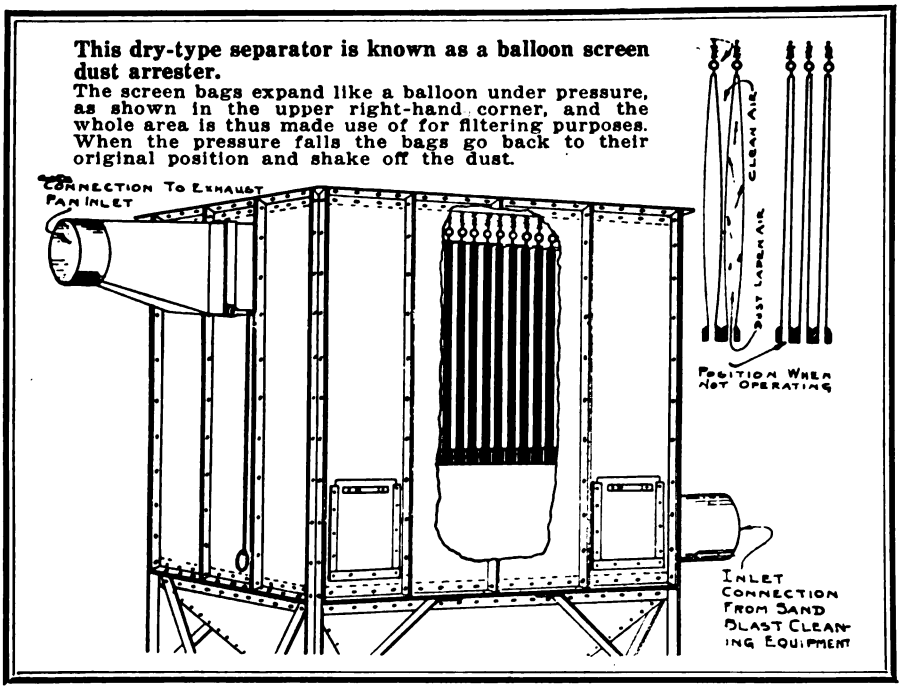
This type of dust collector is used in connection with dryers handling crushed clay or limestone. Here a fan drives the waste gases from the closed dryer stack and blows them to the cyclone separator in which the greater part of the dust is settled in a dry condition. The remainder, consisting mostly of fine dust particles, is delivered from the cyclone separator to the wet centrifugal separator which is here placed on top of the dry separator. In this wet separator the air is forced to travel in several alternating directions and passes through several fine water mists produced by special spraying nozzles. By this treatment the dust is softened and then precipitated by centrifugal force, thus rendering the escaping air practically dustless. This process is also used with other types of rotary kilns such as in cement plants and also with coal dryers. Combination wet and dry separators are often used where it is desired to recover as much of the dust as possible (dry) and also prevent (by the wet process) any fine dust from being discharged into the atmosphere.

particles. It is believed that they are killed by the corona.

The electrical precipitation process is used for the recovery of copper, lead, tin, zinc, silver, gold and other metals carried away in the fumes and dust from sintering machines, reverberatory and blast furnaces, converters, roasters, dryers and other metallurgical equipment. Also, as previously mentioned, it is widely used for the precipitation of acids and other chemical liquids. The electrical process is also used to remove smoke, soot and ashes from boiler plants, gases from engine roundhouses where such discharge would be especially objectionable in the city, and in the removal of solid particles from blast furnace gas before its use in engines or furnaces.

This process has also been used for cleaning air from foundries, and machine rooms, for the precipitation of slate dust from crushing operations, to deposit potash from cement kilns and in many other similar processes. Where the dust has a value such precipitation in many cases more than pays for itself. This process, of course, requires the use of a fan and ducts to carry the air from the process and through the precipitator, the same as any other filtration process.

Because even atmospheric air contains a considerable amount of dust, under normal industrial conditions, it is frequently necessary to remove this dust before the air can be used in processes or in connection with equipment. This also is a problem common to a large number of industries. For removing this dust, wet or dry filters may be used, as was the case in filtering outgoing air.



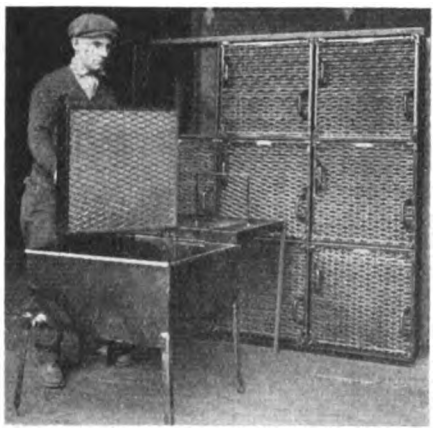
This dry-type separator is known as a balloon screen dust arrester.

The screen bags expand like a balloon under pressure, as shown in the upper right-hand corner, and the whole area is thus made use of for filtering purposes. When the pressure falls the bags go back to their original position and shake off the dust.

There is still another type of filter that is very frequently used for this purpose, but has not been described. This consists of a number of cells or filter units in the form of a shallow steel box having perforated sheet metal covers in the front and back and filled with special filter material. These filter materials may be special filter sheets, filter bodies, or a combination of both, depending upon the purpose of the filter. All the surfaces exposed to the passing air are covered with a thin film formed by dipping the unit into a non-evaporating, non-inflammable viscous and adhesive solution. The dust particles in the air are deposited upon this adhesive solution as the air passes through the filter material. The sections or cells are cleaned by dipping them in a solution which dissolves the viscous material which has caught the dust and washes the dust away with it. The filter unit is then dipped into a fresh viscous solution, allowed to drain and is again ready for use. A few spare units are kept on hand to be inserted when units are removed for cleaning. The cleaned unit then becomes a spare. The length of time between each cleaning depends upon the amount of dust handled. Some of these filter installations and the method of cleaning are shown in accompanying illustrations. Each of these is rated at a stated capacity.

In any installation it is merely a problem of providing enough filter units to handle the required volume of air. This type of filter may be used as well for handling outgoing air, although in general it is not necessary to remove as high a percentage of dust as it is capable of doing. A very common use of these filters is in connection with the inlet of air compressors. Removing solid material from the air prevents scor-

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One of the steps in cleaning a sectional filter unit.

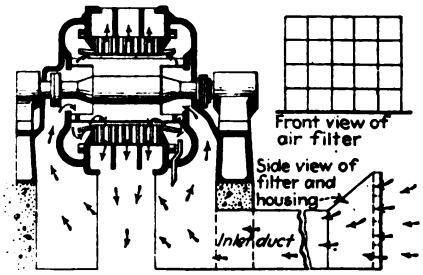
A unit is cleaned by dipping it into a solution which dissolves the viscous material, which catches the dust, from the surfaces in the filter unit. This also washes the dust away. The clean unit is then dipped in a fresh viscous solution. After draining, as shown here, it is set away to use as a spare at the next cleaning period.

ing of air cylinders and so increases the life of the compressor. In addition, if the dust is removed from the air, there is less danger of it getting into tools, such as air drills and hammers, and interfering with their operation. Filtering is also desirable where compressed air is used in a process, such as, for agitating or aerating liquids. This type of dry filter is frequently used where it is not desired to add any moisture to the air.

Another point to be emphasized in connection with all dust removal problems is that more attention should be placed upon collecting the dust before it has escaped into the room. It is well to give much attention to the attaching of the duct systems and enclosing construction because to do so will assist materially in reducing the amount of dust escaping. In modern systems, the machines and conveyors are connected to the exhaust fans in such a way that the dust is removed at the point where it originates.

The preceding articles of this series on materials which are handled by air have so far covered only light dust, fumes and other products which float to a certain extent in air. However, air is used to a considerable extent to carry much heavier materials. One of the most common of these is shavings. In addition, air is also used to carry wool, cotton and many solids in a pulverized and semi-pulverized form. The use of air for this purpose will be discussed in a later article.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and other articles which are appearing in this series: The Air Conditioning & Engineering Co., St. Louis, Mo.; Allen & Billmyre Co., Inc., New York City; American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; E. B. Badger & Sons Co., Boston, Mass.; Bentz Engineering Corp., Newark, N. J.; Buffalo Forge Co., Buffalo, N. Y.; Carrier Air Conditioning Co. of America, Buffalo, N. Y.; Carrier Engineering Corp., Newark, N. J.; The Clarage Fan Co., Kalamazoo, Mich.; The Cooling Tower Co., Inc., New York City; The Dust Recovering & Conveying Co., Cleveland, Ohio; General Electric Co., Schenectady, N. Y.; Globe Ventilator Co., Troy, N. Y.; Green Equipment Corp., Chicago, Ill.; Holly Pneumatic Systems, Inc., New York City; Ilg Electric Ventilating Co., Chicago, Ill.; The MacLeod Co., Cincinnati, Ohio; The Martindale Electric Co., Cleveland, Ohio; Mellish-Hayward Co., Chicago, Ill.; Midwest Air Filters, Inc., New York City; D. J. Murray Mfg. Co., Wausau, Wis.; The Northern Blower Co., Cleveland, Ohio; Research Corp., Chicago, Ill.; Reed Air Filter Co., Inc., Louisville, Ky.; Spray Engineering Co., Boston, Mass.; B. F. Sturtevant Co., Boston, Mass.; The Temco Electric Motor Co., Leipsic, Ohio.

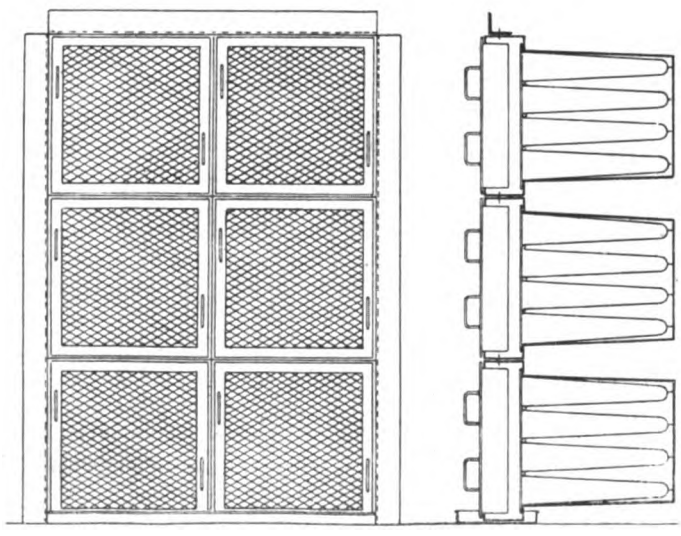


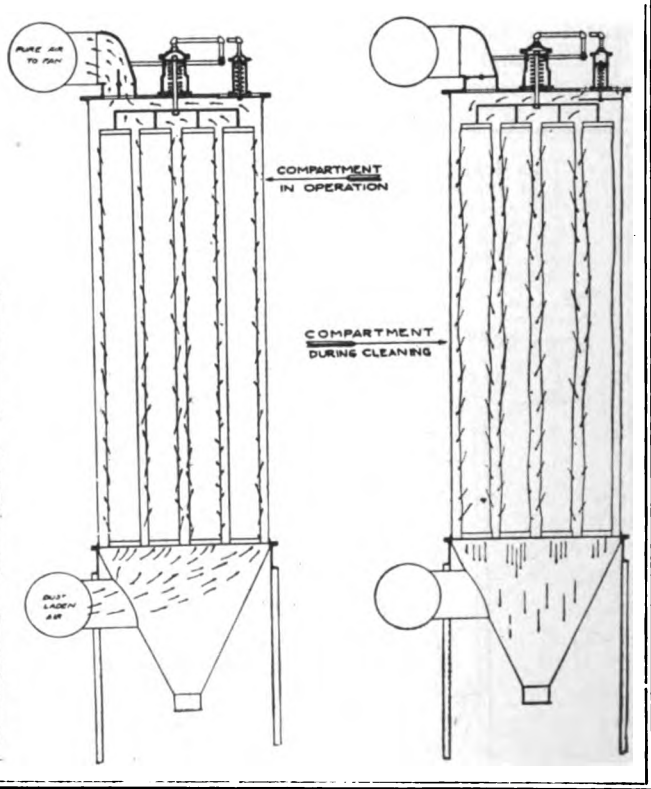
An example of the use of unit sectional filters to clean the air circulated through a generator.

It is quite frequently necessary to circulate air through large generators and other electrical equipment to keep it cool. Unless this air is first cleaned and freed from dust and lint, much of the dust would be deposited upon the windings and form a potential source of trouble.

Two types of dry filters frequently used.

The filter below is a combination of the special unit-type filter, which makes use of a viscous substance on the filter material to retain the dust. Here, in addition, bags with special dust collecting surfaces are inserted behind each unit. The bag filter at the right is operated under pressure and may be used where it is desirable to save the dust. The dust-laden air is drawn into steel cylinders or chambers containing 12 closely-woven cloth bags or sleeves. During the cleaning process the air is reversed and thus removes any deposit on the inside surface.





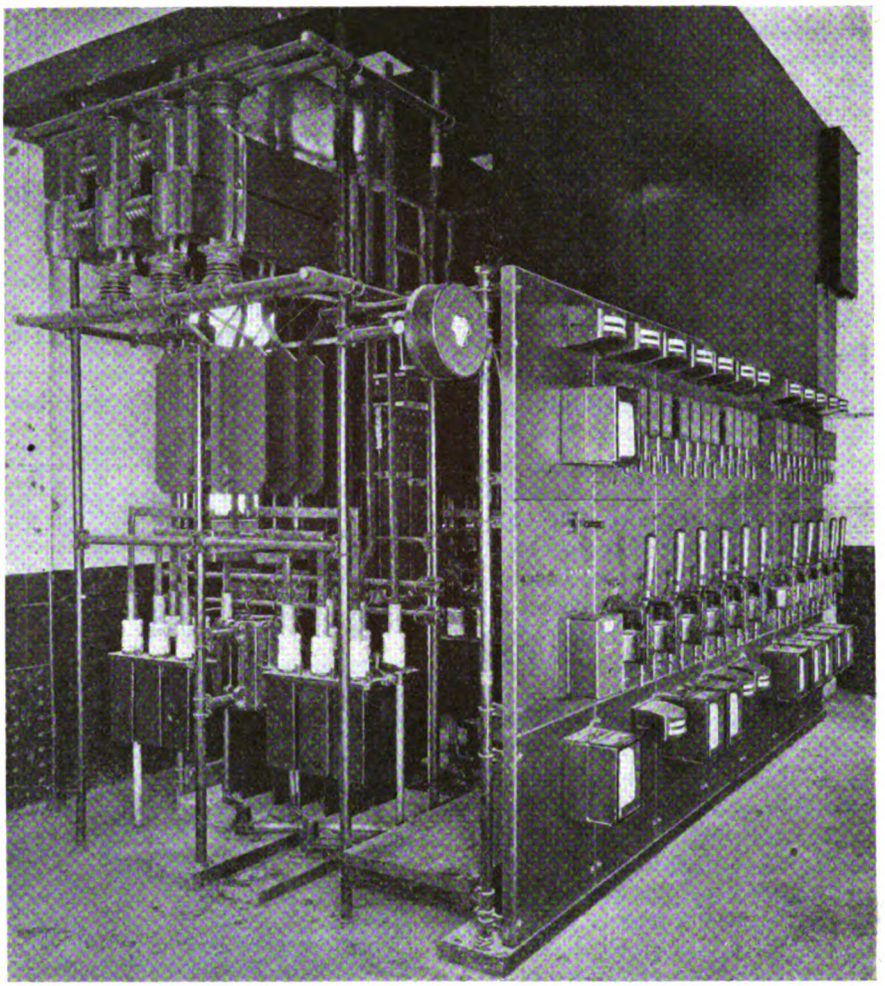
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USEFULNESS AND reliability of any piece of electrical equipment depend to a large extent on the skill and care with which it is installed and the attention that it receives while in service. Some types of equipment naturally require more care than others, but continued neglect of any kind of equipment is certain to cause trouble sooner or later. Oil circuit breakers and switching equipment in general are by no means exceptions to this general rule. Instructions given in this article have been prepared to bring to the attention of operating and maintenance engineers the points that should be given especial attention while this equipment is being installed and after it is in operation.

Electric Power Club Instructions for

Installing Oil Circuit Breakers

And Power Switching Equipment With Pointers on the Care and Operation Thereof



This shows one of the power switchboards in a large tire factory. In order to save space, which was limited, the circuit breakers were mounted back-to-back. This made it possible to put eleven oil circuit breakers on six panels. Note the rigid mounting of the double-deck bus, on the pipe framework. The circuit breakers operate at 440 volts and range in capacity from 600 to 1,200 amp. Courtesy of Electrical Engineers Equipment Co., Chicago, Ill.

IN THE July issue, there were presented instructions which have recently been prepared by The Electric Power Club for the installation, operation and maintenance of power switchboards. Similar instructions which have been prepared to cover the installation, operation and care of oil circuit breakers and power switching equipment are given in this article.

The Electric Power Club is an association of manufacturers of electric power apparatus and control equipment, which was organized to devise standards of practice and construction in the design and application of electrical equipment, and to promote advancements in the production and use of such equipment.

In the introduction to the instructions mentioned above, this comment is made:

"Oil circuit breakers require a considerable amount of intelligent care and inspection to insure their functioning properly at all times.

"Other power switching equipment requires less care, after it has been correctly installed, than most types of electrical apparatus, but neglect of certain fundamental requirements may lead to serious trouble."

These instructions are as follows:

STORAGE

When an oil circuit breaker can be set up immediately in its permanent location and filled with oil, it is advisable to do so, even though it will not be placed in service for some time. The tank should be cleaned and dried before it is filled with oil.

If the breaker cannot be installed in the proper location immediately, and it is necessary to store the equipment, it should be kept in a clean, dry place. It must not be exposed to dirt, to the action of corrosive gases, such as chlorine, or to possible mechanical injury.

If stored outdoors, the breaker must be thoroughly covered to protect it from the weather.

Machined parts of operating mechanisms, etc., should be slushed to prevent rusting; and if the breaker is stored for any length of time, they should be inspected periodically to see that rusting has not started and to insure their good mechanical condition.

Particular care should be taken to protect insulating parts, which might absorb moisture. It is desirable that these parts be stored in a dry room.

LOCATION

The circuit breaker should be placed in a clean, dry place free from the destructive action of acids, alkalies or gases, such as chlorine, and where good ventilation can be secured.

The breaker should be so located that it will be readily accessible for cleaning and inspection. Sufficient space must be provided for the easy removal of the oil tanks.

The instructions sent by the manufacturer should be carefully studied and followed in order to

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secure the best results. It is here impossible to cover in detail the complete rules for installation of each of the different types of oil circuit breakers manufactured, but the following information is given relative to the most important points to be considered:

MOUNTING

On Slate Panels.—When an oil circuit breaker is mounted on a slate panel, do not over tighten the holding bolts and nuts supporting the breaker, as unnecessary strains may crack the slate.

On Framework.—If the oil circuit breaker has been shipped assembled in its framework, it will only be necessary to correctly locate and fasten the frame in position on its foundation. The foundation bolts should be left loose to permit the frame to be properly plumbed and leveled by inserting shims under floor flanges (or feet of frames) where necessary. After this has been done, the foundation bolts should be tightened and the frame securely fastened to its foundation.

The manufacturer's instructions should be carefully followed in regard to properly setting up a frame-mounted breaker shipped partly disassembled. The procedure is:

(1) Set up and properly level the frames.
(2) Carefully install the units on the framework, making sure they are level.
(3) Connect the operating mechanisms.
(4) Inspect contacts and adjust (if necessary) as per instructions sent with the breaker.

Floor Mounted.—Each tank should be placed in position on the floor and leveled. It should not be fastened securely to its foundation until the current breaker mechanism has been correctly aligned.

The manufacturer's instructions should be followed very carefully, making sure of the following points:

(1) Carefully install the units on the foundation, making sure they are level.
(2) Connect the operating mechanisms so they will work freely as per instructions.
(3) Inspect contacts and adjust, if necessary, as per instructions sent with the breaker.

Bushings.—The bushings (insulators) must not be allowed to strike against parts of the framework, panel or other objects, when installing or handling the breaker. Bushings are often broken, cracked or loosened in their supports by unnecessary jars due to careless handling.

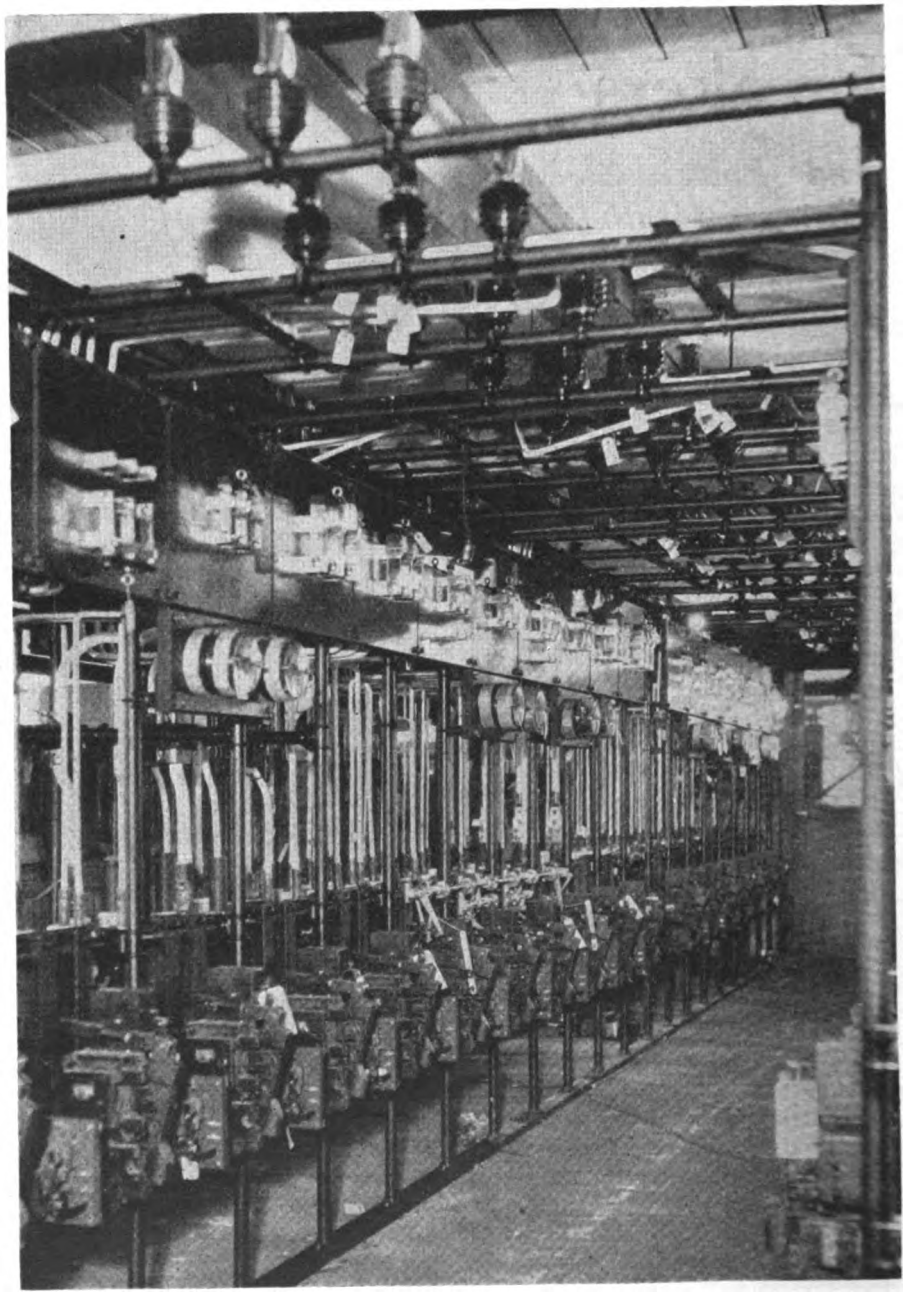
Where heavy bushings have to be mounted in position by the purchaser, a rope sling will be found convenient for proper handling. The bushing must be lowered into place very carefully without letting the porcelain petticoating strike the sides of the framework, etc., as this may crack or otherwise injure the bushing.

In the case of high-voltage bushings which must be filled with oil, the drain plug in the casting at the lower end of the bushing should be inspected to see that it is tight; otherwise the bushing will leak oil.

Operating Mechanisms.—As the proper alignment of the links, pins, etc., of the operating mechanisms is essential to the proper operation of the oil circuit breaker, these should be carefully checked and the manufacturer's instructions followed explicitly. A breaker must not be operated until a thorough inspection is made of the mechanism.

For large, triple-pole breakers, the connecting rods or couplings between units must be aligned before satisfactory operation is possible. The connecting rods or couplings must be adjusted so that, in closing the breaker, the contacts of each unit are made at the same instant and in opening the breaker, the contacts of

Here is a well-planned installation of circuit breakers.
This is a 440-volt, three-phase, 60-cycle installation. The advantages of pipe framework as a mounting structure are clearly apparent in this and some of the other illustrations. Note how the buses are mounted on pipe supported at the top of this and another similar board, part of which can be seen at the entreme right of this illustration. Courtesy of Condit Electrical Mfg. Co., Boston, Mass.



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each unit break at the same instant.

Contacts.—Contacts should be adjusted in strict accordance with the manufacturer's instructions sent with the individual oil circuit breaker.

Before opening or closing the contacts they should be coated with vaseline. (In most cases this is done by the manufacturer before shipment.)

Manually-Operated Oil Circuit Breakers.—If the lever, handle or crank has not been connected to the operating mechanism by the manufacturer for operating the breaker manually, this should be done, making sure that all parts (shafts, pins, etc.) are properly lined up as per the manufacturer's instructions. Before attempting to bend or force parts together when installing, the manufacturer's instructions should be referred to to see if they have been explicitly followed. Much time and trouble may be saved by avoiding too hasty action.

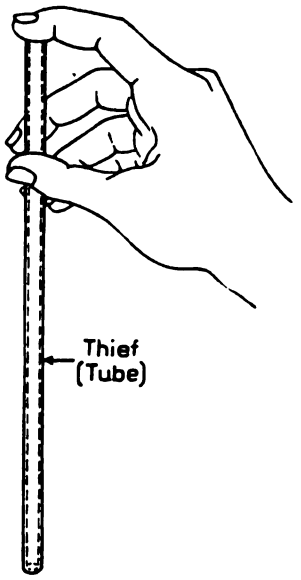
Electrically-Operated Oil Circuit Breakers.—The connecting links, shafting, etc., between the breaker operating mechanism and the mechanism (solenoid, motor or other device) supplied for electrical operation, must all be carefully aligned. The breaker should be slowly operated by hand before it is operated electrically. The operation should be observed to see that it is smooth throughout the closing and opening of the breaker, that no binding occurs, and that no excessive play is noticeable between parts.

Sampling and Testing Oil

When sampling oil the sample container should be a large mouthed glass bottle. The bottle should be cleaned and dried with gasoline, free from moisture before it is used. A cork stopper should be used.

The sample of oil for dielectric tests should be at least 1 pt. (16 oz.) and if a number of tests are to be made, 1 qt. (32 oz.).

Test samples should be taken only after the oil has settled for some time, varying from 8 hr. for a barrel to several days for a large oil circuit breaker tank. Cold oil is much slower in settling and may hardly settle at all. Oil samples from large oil circuit breakers should be taken from the valve at the bottom of the tank. Oil samples from small oil circuit breakers which have no valves, and from barrels, should be taken from the bottom. A brass or glass "thief" can be conveniently used for this purpose. The same method should be used for cleaning the "thief" as is used for cleaning the container for the oil sample.



This shows how to hold the "thief" for taking samples of oil from small oil circuit breakers.
The oil tank should be lowered and the sample taken at a point about half-way between the closed contacts and the bottom of the tank. The finger should be held tightly over the upper end of the thief or tube, while the lower end of the thief is pushed down in the oil to the proper level. When the finger is removed the oil will flow into the thief. The upper end should again be closed with the finger, after which the thief may be withdrawn from the oil and the sample deposited in any suitable container. Courtesy of General Electric Co., Schenectady, N. Y.

When drawing samples from the bottom of a large oil circuit breaker or large tank, sufficient oil must first be drawn off to make sure that the sample will be composed of oil from the bottom of the tank, and not from the oil stored in the sampling pipe. A glass receptacle is desirable so if water is present, it may be readily observed. If moisture is found, an investigation of the cause should be made and a remedy applied. If water is not present in sufficient quantity to settle out, the oil may still contain considerable moisture in a suspended state. It should be tested for dielectric strength.

In testing oil for dielectric strength, some standard device for oil testing should be used. The standard oil testing spark gap has disk terminals 1 in. in diameter spaced 0.1 in. apart. The testing cup should be cleaned thoroughly to remove any particles of cotton fibre, etc., and rinsed out with a portion of the oil to be tested.

The spark gap receptacle (cup) should be nearly filled with oil and allowed to stand for a few minutes to give air bubbles time to escape before making the test.

The rate of increase in voltage should be about 3,000 volts per second. Five breakdowns shall be made on each filling and then the receptacle emptied and refilled with fresh oil from the original sample. The average voltage of 15 tests (5 tests on each of 3 fillings) is usually taken as the dielectric strength of the oil. It is recommended that the test be continued until the mean of the averages of at least three fillings is consistent.

The dielectric strength of the oil when shipped is at least 22,000 volts tested in the standard gap. If the dielectric strength of the oil in an oil circuit breaker in service tests at less than 16,500 volts, it should be filtered. New oil of less than the standard dielectric strength (22,000 volts) should not be put in the oil circuit breaker tank.

Drying.—In removing moisture from the oil, it is preferable to filter from one tank or barrel and discharge into another, although if necessary, it may be drawn from the bottom of a tank or barrel and discharged at the top. When there is much water in the oil, it should be allowed to settle; then the moisture should be drawn off and any moisture remaining treated separately.

Filling Tanks.—Before the oil circuit breaker is filled with oil, all accessories, such as valves and gages must be fitted to the breaker and made oil tight. The threads should be filled with shellac before putting in place.

When drums of oil are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and until they are thoroughly dry. If the installation is outdoors, the preparation and filling of the breaker tank should be done on a clear, dry day or protection of some kind provided against moisture being absorbed by the oil during the filling process.

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur in rubber and may cause trouble, as sulphur attacks copper.

It is very important that the surface of the oil when cold (25 deg. C.) be at the proper oil level indicated by the gage or marking on the tank.

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Before making any electrical connections every precaution must be taken to see that all leads to be connected to the oil circuit breaker are dead.

Leads should be brought down from above the circuit breaker if possible. Ample room must be provided between these leads and parts of the station, such as walls, channels and framework.

All terminals must be fastened securely to the leads and tightly clamped to the connection studs.

Connections to the breaker are made by copper tube terminals or connection bars fastened to the end of the bushing. When tightening the terminal or clamp bolts, care must be taken not to turn the stud in the bushing (insulator).

All joints must be clean, bright and free from dents or burrs.

All nuts on the current-carrying stud must be securely bolted against the terminal lugs to obtain good contact. The nut should turn freely on the stud. If the nut does not turn freely it should not be forced down with a wrench, but should be tapped lightly on its outer surfaces with a hammer and at the same time turned by hand. A nut that cannot be worked down in this manner will ruin the thread if any attempt is made to force it. If the joints are not made correctly, dangerous heating of the breaker may result.

Cables should be properly supported so that the breaker is not subjected to unnecessary strains. The studs should not carry cable or bus bar strains. Any strain which at first has no apparent effect on the stud alignment will in time force the studs to take up a new alignment, due to vibration during the opening and closing of the oil circuit breaker and poor contact may result.

To avoid heating, the connecting leads must be of a current-carrying capacity at least equal to that of the current-carrying part of the breaker.

To prevent weakening of the insulation as much as possible, sharp turns, corners and edges should be avoided, for insulated wiring. The radius of bends for rubber-covered, varnished-cambric or lead-covered cable should be never less than six times the outside diameter of the cable. With small braided conductors, the radius of bends may be five times the outside diameter of the cable.

Control Wiring.—All control wires should be run in conduit in so far as is practicable.

Control wires must be run separately and remote from high-tension leads and must not be run in the same duct or even run parallel to the high-tension leads unless the distance separating the two sets of wiring is sufficient to prevent possible communication between them as a result of short-circuits.

The control wiring should be so installed that trouble on one oil circuit breaker cannot be communicated to the control wiring of another breaker.

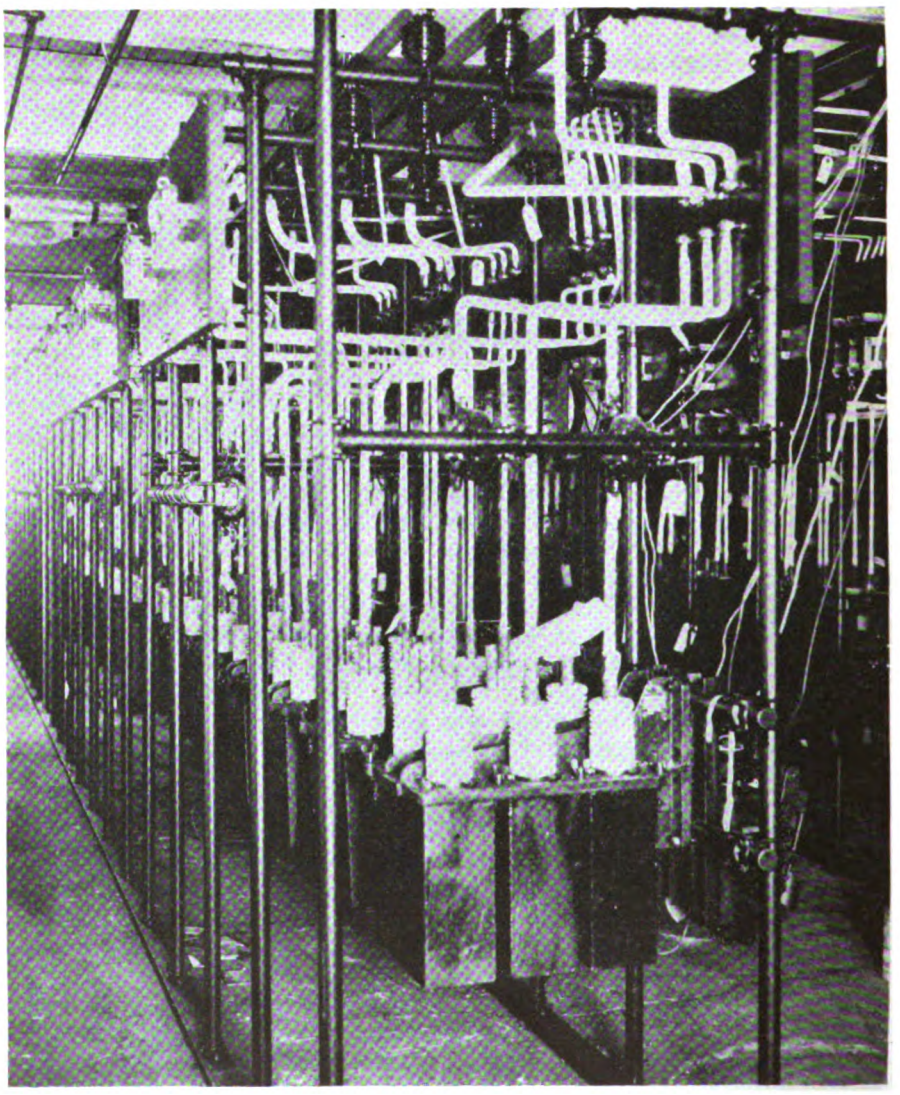
Ground Connections.—The frame of each unit of an oil circuit breaker should be permanently grounded. Usual practice is to connect a heavy cable to the frame and to the ground.

A good, permanent, low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all, since it gives a false feeling of safety to those working around the equipment and also may result in ultimate loss of life or damage to the apparatus.

AUXILIARIES

Protective and Alarm Relays.—Relays supplied in connection with the proper operation (for tripping, sounding an alarm, etc.) of oil circuit breakers should be wired up in accordance with the connection diagrams furnished by the manufacturer. As these relays are rather delicate mechanisms, because of the close regulation they provide, frequent inspection of the relays should be made. Operating tests under actual conditions are necessary and both mechanical and electrical performances should be noted. The relays must be kept free from dust and dirt and the settings should be inspected periodically to prevent the operator from abusing the equipment by defeating some of the protective or operating features of the apparatus.

Relays should be adjusted only



Accessibility for inspection and maintenance was well taken care of in this 440-volt installation.
The method of mounting the circuit breakers, buses, and so on, on the pipe framework is well shown here.

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within limits determined by the manufacturer. If observance of this does not provide operation essential to the application, the manufacturer should be consulted. The instructions supplied with the relays should be carefully followed.

Dashpots.—Oil dashpots should be examined periodically to see that they are properly filled with suitable oil, in accordance with the manufacturer's instructions. Bypasses and check valves should be examined and cleared. Dirty oil should be replaced. Substitution of oils other than specified or furnished by the manufacturer should be avoided and only in extreme emergencies should this be done, and then only by authorized and competent persons. If it is necessary to supply oil temporarily for dashpots, oil should be chosen that will not become thick at the lowest temperature to which it will be subjected. Ice machine oil is suitable for this temporary use. Clean oil having the proper characteristics is essential for correct operation.

Tripping Coils (Automatic Operation).—Tripping coils used in the secondary of instrument current transformers are calibrated in secondary current values, which, when multiplied by the ratio of the transformer used, give the corresponding primary or line current values. The markings on the calibrating tubes represent the ampere values required to lift the plunger and trip the oil circuit breaker.

Tripping coils used in the secondary side of bushing current transformers are calibrated in primary current values and the markings on the calibrated tubes represent the secondary current values required to trip the breaker.

Undervoltage (Low Voltage) Release.—The proper holding and releasing action of undervoltage coils and mechanisms is dependent upon both mechanical adjustment and upon the application of the voltage (and frequency for alternating-current systems) specified on the nameplate. These devices should be inspected periodically to insure that their operation is not too violent, causing unnecessary strains to be placed on them.

Alternating-current release mechanisms should be examined periodically to see that the iron circuit is properly sealed and that the pole pieces are cleaned of rust and that they make a true, flat contact. Care on this point will prevent or lessen humming and failure of coils from excessive current due to open iron circuits.

When undervoltage devices are supplied for use in series with resistors, the connections should be carefully checked before full voltage is thrown across the operating coils.

After an oil circuit breaker has been installed with all mechanical and electrical connections completed, the following inspections and tests should be made:

(1) See that the breaker is properly set up and leveled on its supporting structure (panel, pipes, structural iron or steel frame, etc.)
(2) See that all bearing surfaces of the operating mechanism have been lubricated.
(3) Close the breaker slowly by hand (when it is dead) noting that the operating rod (or rods) and contacts are properly adjusted for correct alignment. Good contact should be made with the breaker closed.
(4) See that the tanks are filled with oil to the proper level (oil line or gauge.)
(5) Inspect all insulated wiring to see that no damage has resulted during the process of installing it.
(6) Test the wiring for possible grounds or short circuits.
(7) See that all current-carrying parts outside the oil tanks are correctly insulated in accordance with standard practice.
(8) See that all joints, whether bolted joints of copper bars, or soldered (or clamped) joints made with wires or cables, are made correctly.

Electrically Operated Oil Circuit Breakers.—Electrically operated oil circuit breakers should be operated manually (by hand) first, noting that all parts move freely and without binding. After careful inspection has shown all parts to be in proper working order during the manual operation, the breaker may be operated electrically at normal operating voltage.

The safety and successful functioning of connected apparatus depend upon the proper operation of the oil circuit breaker. Therefore, the circuit breaker must have regular, systematic care and inspection. The points that require especial attention during the inspection of oil circuit breakers are given above.

Points That Need Special Attention During Inspection of Oil Circuit Breakers

(1) Be sure the breaker and its mechanism are disconnected from all electric power, both high voltage and operating current, before inspecting or repairing.
(2) Inspect the operating mechanism periodically and lubricate all bearing surfaces of the mechanism regularly with a good quality of sperm.
(3) Keep the bearing surfaces of the toggles, rods and levers adequately oiled, as the mechanism cannot operate properly with "sticky" bearings.
(4) Keep the mechanism clean.
(5) Examine the contacts frequently. See that they are aligned and that contact surfaces bear with firm, uniform pressure. Replace badly pitted or burned contacts before they are burned away sufficiently to cause damage to other parts of the apparatus. If the contact surfaces are only roughened, they may be smoothed down with a fine file or fine emery cloth.
(6) Be sure the breaker is dead before lowering and removing the tank in order to examine the contacts.
(7) Be sure the breaker frame is well grounded.
(8) See that bolts, nuts, washers, cotter pins and all terminal connections are in place and tight.
(9) Inspect the bushing (insulator) supports, as the vibration due to the operation of the breaker may cause the bushings to move slightly and result in misalignment of contacts.
(10) Clean the bushings at regular intervals where abnormal conditions prevail, such as salt deposits, cement dust or acid fumes, to avoid flashovers as a result of the accumulation of foreign substances on their surfaces.
(11) See that the oil is kept at the proper level in the tank (or tanks) and that the proper dielectric strength of the oil is maintained. (See instructions on page 375 for testing oil.) Add new oil occasionally to replace the slight evaporation.
(12) Change or filter the oil every six months (or more often for heavy service).
(13) Filter the oil after successive openings under load (short-circuit, etc.) if it shows signs of carbonization, or if the dielectric strength is lowered because of dirt or suspended matter therein. Test the oil before replacing it in the tank. Carbonization is indicated by a flaky, black precipitate which floats in the oil when disturbed.
(14) Do not allow moisture to come in contact with the oil when filtering.
(15) Remove all oil once a year and thoroughly clean the tank (or tanks) and other parts (lining, etc.)

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Electrically Operated Oil Circuit Breakers.—At all inspections the oil circuit breaker should be operated by hand to see that the mechanism works smoothly and correctly before it is operated electrically.

A breaker should not be operated electrically, with the oil tanks removed, any more than is absolutely necessary.

It is again strongly urged that the manufacturer's instructions for each oil circuit breaker be carefully read and followed.

It is recommended that sufficient spare parts be carried in stock to enable the operators of oil circuit breakers to promptly replace any worn, broken or damaged parts. It will be readily appreciated that a stock of parts reduces delays in service and saves time and expense. The manufacturer will advise the purchaser upon request.

Power Switching Equipment

Power switching equipment, as the term is used here, includes the following devices:

Bus supports
Single-pole, hook, stick-operated switches
Gang-operated disconnecting switches and mechanisms
Air-break, horn gap switches and mechanisms
Choke coils
Primary fusible cutouts and mountings
Fusible cutouts, resistors and mountings for potential transformers
Conductor fittings
Mounting structures

Handling

Upon arrival at destination, trucking and handling should be done with due regard to the fact that porcelain is used in practically all switching equipment and that it is easily broken.

All switching equipment should be properly stored to protect it.

Instructions for Assembly

As it is the manufacturer's desire that equipment give the most satisfactory results, instructions for assembly or drawings showing construction details should be followed.

Alignment.—Switching equipment should be carefully lined up on the supporting structure, care being taken to see that the structure surface on which the bases are mounted is flat and true, otherwise, the bases may be twisted when bolted to the structure. This will throw parts out of line and throw undue strain on the insulating units with resultant difficulties in operation and proper contact alignment.

Rigidity.—All switching equipment should be rigidly bolted in place and the supporting structure should be sufficiently stiff so that it will not spring or give to the extent that it interferes with proper operation of the equipment.

Rigging and Handling.—When handling switching equipment for erection, it is recommended that it be fully assembled and adjusted before placing it in position in so far as the size of the equipment will permit, as this will facilitate final adjustments.

Rigging which is used for erecting the equipment should be attached to the bases and not to the insulator units, contacts or operating parts which might be injured. All such parts should be kept clear of the rigging. When in place, adjustments should be made without weight or strain being placed on the insulators and current-carrying parts.

Personal Safety in Installation

The usual Safety First precautions should be carefully followed.

When erecting switching equipment particular care should be given to the following:

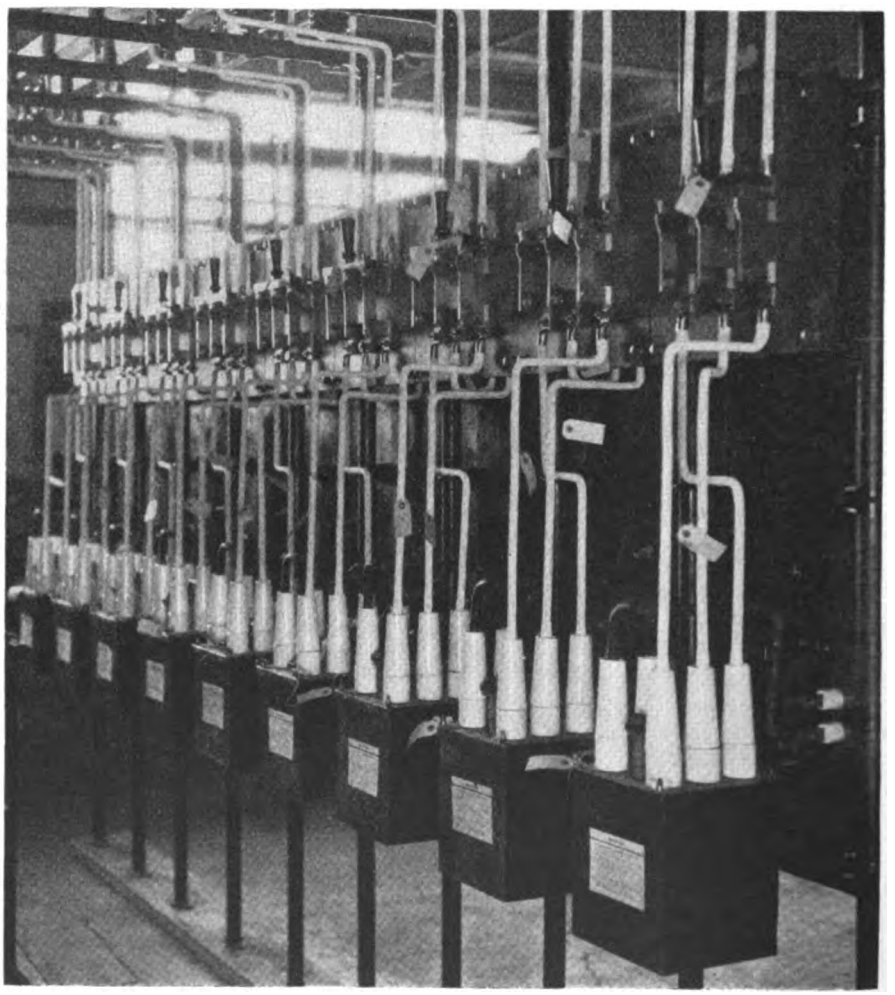
(1) Make absolutely sure that the line on which men are working or erecting equipment is dead.
(2) Protect the workers adequately from adjacent live parts by barriers, screens, etc.
(3) Follow the National Electrical Safety Code as well as local requirements.

Erection of Switching Equipment

Adequate means for handling switching equipment should be used. Attention should be given to the strength of rigging and the use of sufficient scaffolding to permit of erecting the equipment without subjecting the insulators and mechanical parts to strains which might

Simplicity and neatness characterize this 440-volt, nine-panel, power switchboard, of which a rear view is shown here.

These oil switches operate at 440-volts, three-phase.



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distort and interfere with the successful operation of the equipment.

In addition to following the manufacturer's instructions carefully, it is recommended that the following points be considered.

Placing Switches.—Hook stick operated switches should be so placed that they are safely accessible for operation by means of the hook stick and without causing the operator to get too near live parts, lines, buses or insulators.

Cleaning Equipment.—After the switching equipment has been installed and connections completed, it should be carefully gone over and cleaned. Special attention should be given to cleaning the insulator units, contacts and moving parts.

Dead Ending.—Incoming or outgoing lines or conductors on which there is any appreciable strain should be provided with adequate, strain-type insulating supports in order to remove from the switching equipment any undue strains which might cause poor contact or throw the equipment out of proper alignment.

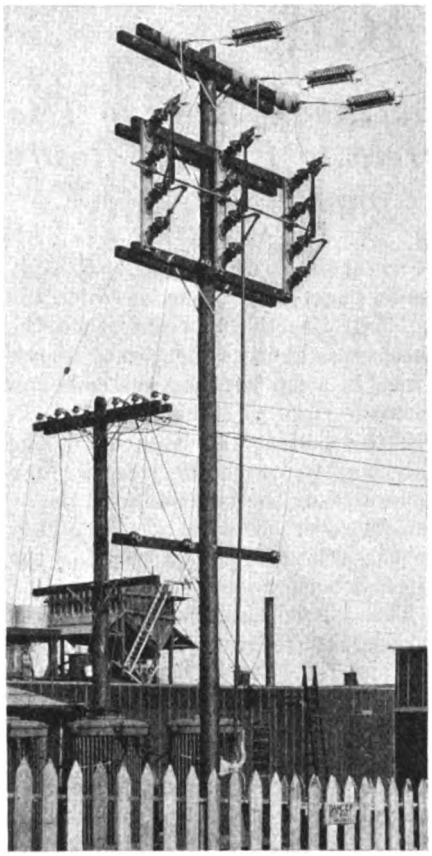
Lines should be anchored to the structure or nearby poles or towers. If lines are anchored to the tower, they should be arranged to give direct strains without tendency to twist the tower and throw the bases of equipment out of line.

If wood poles and wood cross arms are used for the lines, it is recommended in general that the insulators on steel structures to which such lines are connected be provided with a higher factor of safety than the line insulators. Where steel poles or towers are used, this factor of safety is not so essential unless the station is subjected to fumes, smoke or other dirt.

Conductors.—It is important that bus arrangements which make use of strain-type insulation be rigidly installed. Owing to the physical dimensions of the structure, such conductors should be under sufficient strain to keep them from excessive swaying.

Conductors should be run as nearly as possible in straight lines and should be supported sufficiently to withstand the mechanical load and magnetic stresses.

Expansion and contraction of conductors due to temperature changes may develop heavy stresses on the supporting insulators and connected equipment. In long, heavy bus structures care should, therefore, be taken to see that means are provided to allow for expansion. The importance of this question depends upon the length of conductors and the possible temperature variation.



This does not look like a temporary installation, but it is.

Oftentimes "temporary installation" is only another term for slip-shod workmanship, with little or no planning back of it. This is not true of the installation shown above. The incoming lines carry three-phase power at 25,000 volts. As will be noted the disconnecting switches, which are provided with high-tension fuses, are controlled by the lever on the pole, just above the fence. Suspension-type choke coils were used to good advantage here.

The cantilever strength of conductor supports is becoming an increasingly important factor due to the weight of buses and electro-magnetic stresses under short-circuit. For this reason the height of bus supports should be kept down to a minimum consistent with the full flashover value of the porcelain body.

On alternating-current conductors the conductor clamps should not form a closed magnetic circuit around the conductor.

Switching Equipment Connections.—Contacts should be clean and smooth. Excess strains should be carried by auxiliary supports. Soldered connections should be carefully made to insure that the joint is completely filled with solder. It is recommended that soldered connections be relieved from undue mechanical strains.

Ground Connections.—All switching equipment should be grounded in accordance with the best accepted practice. (See National Electrical Safety Code requirements for grounding.)

Steel frames or structures for supporting equipment should be adequately grounded at several points to guard against poor joints.

All grounds for the switching equipment and structure should be independent of the lightning arrester ground.

Fusible Cutouts.—Primary fusible cutouts of the expulsion type should be provided with good clearance in the direction in which they blow and facilities should be provided for operating them without requiring the operator to get near the expulsion end.

Mounting Structure

Location.—Consideration should be given to the location of the structure relative to the question of smoke, dirt and fumes. It is desirable to locate the structure in a place as free from such conditions as possible as they may cause rapid deterioration of the conductors and contact joints, corrode parts, cause them to make imperfect contact and reduce the flashover value of the insulation.

Foundations.—The foundations should be carefully prepared and of sufficient size, depth and strength to adequately withstand all possible strains which the structure may be required to meet.

Plumbing and Alignment.—It is important that the structure be carefully plumbed and aligned, otherwise the equipment may not line up properly and in addition to bad appearance might give difficulties in mounting and operating.

Inspection

It is important that after installation and before placing in service the mounting structures and equipment be carefully inspected and checked with the manufacturer's drawings. The following are suggested as details which should be carefully gone over:

(1) Examine insulator units.
(2) Examine contacts.
(3) Examine switch locks.
(4) Examine mechanisms, with reference to operation, lubrication, and

(*Please turn to page 402*)

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Here Are Some

Practical Pointers And Winding Rules

For D. C. Armatures That Show How to Use Winding Data and Will Help to Prevent Costly Mistakes in Rewinding and Connecting

By A. C. ROE

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and

D. H. BRAYMER

Consulting Editor, Industrial Engineer,

THE PRACTICAL use that can be made of the forms for taking and recording winding data, which were discussed in the June and July issues of INDUSTRIAL ENGINEER, is shown in this article and others that will appear in later issues. Details are given for starting and winding lap- and wave-wound armatures and certain practical rules are presented that will help the winder to prevent mistakes and make sure that the proper coil layouts and connections to the commutator are used for different numbers of slots and commutator bars, with different numbers of poles in the motor.

THIS article supplements those that appeared in the June and July issues, dealing with the methods of taking and recording rewinding data, and the forms that are convenient to use in this connection. Actual illustrations are given to show how to apply the data recorded to a particular job in the shop. References are made to illustrations that appeared in the June and July issues and it will be well to have these available when reading this article.

WINDING RULES THAT GOVERN LAP WINDINGS

A lap winding can have any number of bars, even or odd, but as a general rule the total number of bars selected must make possible a balanced winding; that is, there should be an equal number of coils per circuit or leg, particularly on cross-connected armatures; this means the total number of bars will be a multiple of the number of poles, in cases where a balanced winding is desired. There are a number of cases, however, where an odd number of coils can be used, so that there is no set rule as to the number of bars and coils that can be connected up into a lap winding.

In a lap winding, left-hand or right-hand coils do not affect the polarity or rotation of the machine. A left-hand coil is one in which the top half of the coil is on the left-hand side when the coil is in place on the armature and the observer faces the commutator end of the armature. The coils shown in the data forms, Figs. 4 *A* and 5 *A* (July issue, page 335) are left-hand coils. A right-hand coil (Fig. 5 *B*, July issue, page 335) is one in which the top half lies to the right when the observer stands as mentioned above. Thus, in a lap winding the coils can be made right or left without affecting the polarity or rotation. The only way in which the polarity of a generator or the rotation of a motor can be reversed, with a lap winding on the armature, is by crossing the top and bottom leads of each coil.

The above statements can be checked by referring to Figs. 1 *A*, 1 *B* and 1 *C*. Fig. 1 *A* shows part of a left-hand lap winding. Coil *A* connects to bars *1* and *2*; coil *B* to bars *2* and *3*, etc. If it is assumed that a positive brush is in contact with bars *3* and *4*, then coil *C* (marked with a cross) will be short-circuited by the brush and will not carry any working current at all.

In a lap winding there are as many circuits or current paths as there are poles, and also as many brush positions as there are poles. From each positive brush, therefore, there must be two paths through the winding to the negative brushes. In Fig. 1 *A* one path starts at bar *4* to the left, then goes to slot *4* as shown by the arrow, then to slot *10*, to bar *5*, to slot *5*, to slot *11* and to bar *6*. The arrows on slots *4* and *5*

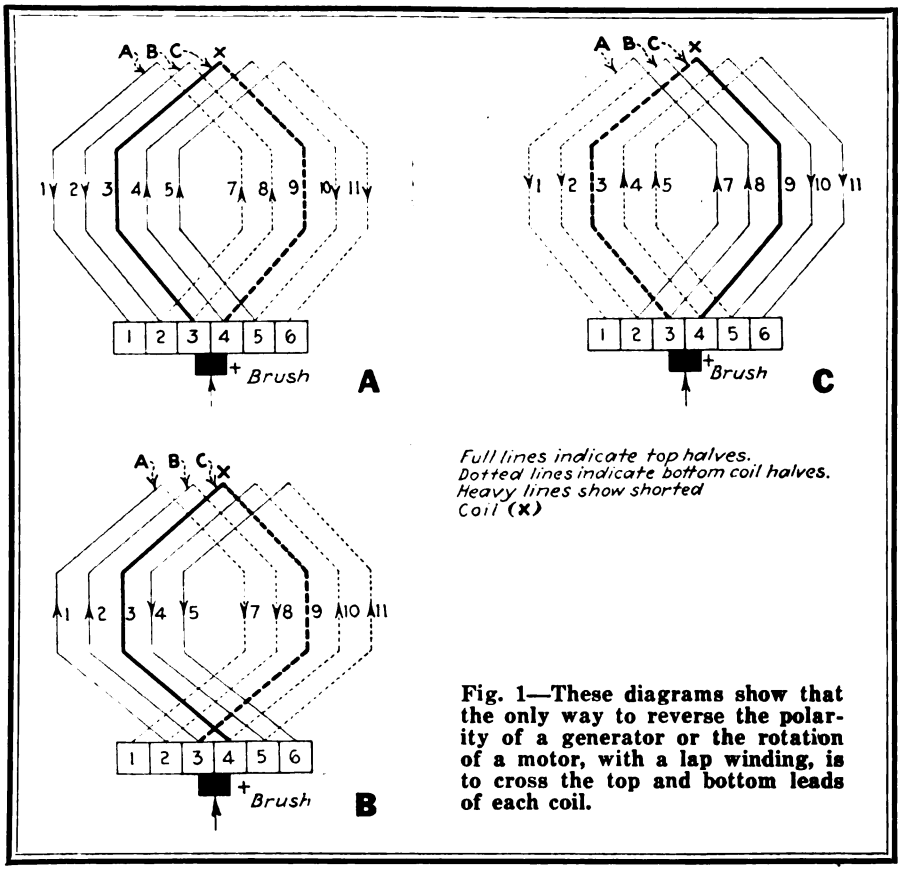


Fig. 1—These diagrams show that the only way to reverse the polarity of a generator or the rotation of a motor, with a lap winding, is to cross the top and bottom leads of each coil.

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point up, and on slots *10* and *11* the arrows point down. The second path starts at bar *3*, goes up through slot *8*, down through slot *2* to bar *2*, up through slot *7*, and down through slot *1* to bar *1*. The arrows on slots *1* and *2* point down, while the arrows on slots *7* and *8* point up. The short-circuited coil forms the dividing line between the up arrows on slots and the down arrows on slots.

By comparing Fig. 1 *B*, which shows a right-hand winding, with Fig. 1 *A* it will be noticed that coil *C* is shorted, and that the arrows on slots *1* and *2*, *4* and *5*, *7* and *8*, *10* and *11*, in Figs. 1 *A* and 1 *B* are in the same direction. Hence, a left-hand or right-hand coil does not affect the rotation or polarity.

Next, refer to Fig. 1 *C*, which is practically the same as Fig. 1 *A*, except that the leads have been crossed; that is, the top lead of coil *A*, Fig. 1 *C*, connects to bar *2* and the bottom lead to bar *1*, which is just the reverse of Fig. 1 *A*, in which the top lead of coil *A* connects to bar *1* and the bottom lead to bar *2*. Then with the brush in the same position as used in Figs. 1 *A* and 1 *B*, coil *C* will be shorted as before, but the right-hand path starts at bar *4* and goes to the right, up through slot *10*, down through slot *4* to bar *5*, up through slot *11* and down slot *5* to bar *6*. The left-hand path starts at bar *3*, goes to the left, up through slot *2*, down slot *8* to bar *2*, up slot *1* and down slot *7* to bar *1*. By comparing the directions of the arrows in the slots of Fig. 1 *C*, with the directions of arrows on the slots of Figs. 1 *A* and 1 *B*, it will be found that slots *1* and *2*, *10* and *11*, have up arrows in Fig. 1 *C*, while the same slots in Figs. 1 *A* and 1 *B* have down arrows. Slots *4* and *5*, *7* and *8* of Fig. 1 *C* have down arrows while the same slots in Figs. 1 *A* and 1 *B* have up arrows. In a motor with the same field coil polarity, the direction of rotation of the armature in Figs. 1 *A* and 1 *B* would be opposite to that of the armature shown in Fig. 1 *C*. In a generator the direction of rotation would be the same, but the currents induced in the armature would change the polarity of the brushes.

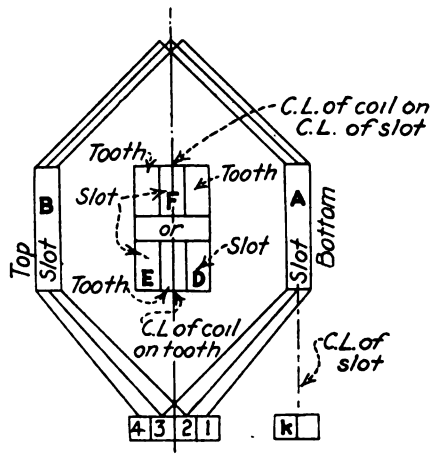


Fig. 2—Here is a diagram that can be used under any condition encountered in laying out coils for a lap winding.

Two arrangements of slots are shown. The top arrangement is for use when the center line of the coil falls in the center of a slot, while the lower arrangement is used when the center line of the coil falls on the center of a tooth. The relative position of the center line of the coil to the center line of the mica, bar, slot and tooth, under different conditions, is given in the rules in the next column on this page.

The following rules refer to the relative position of the center line of the coils, to the center line of the mica, bar, slot and tooth.

(1) In Fig. 2 when the number of coils per cell is odd, one, three, five, etc., and the coil pitch is one and an even number as 1-and-8, 1-and-10, etc., the center line of the coil will fall on the center line of the tooth and the mica.

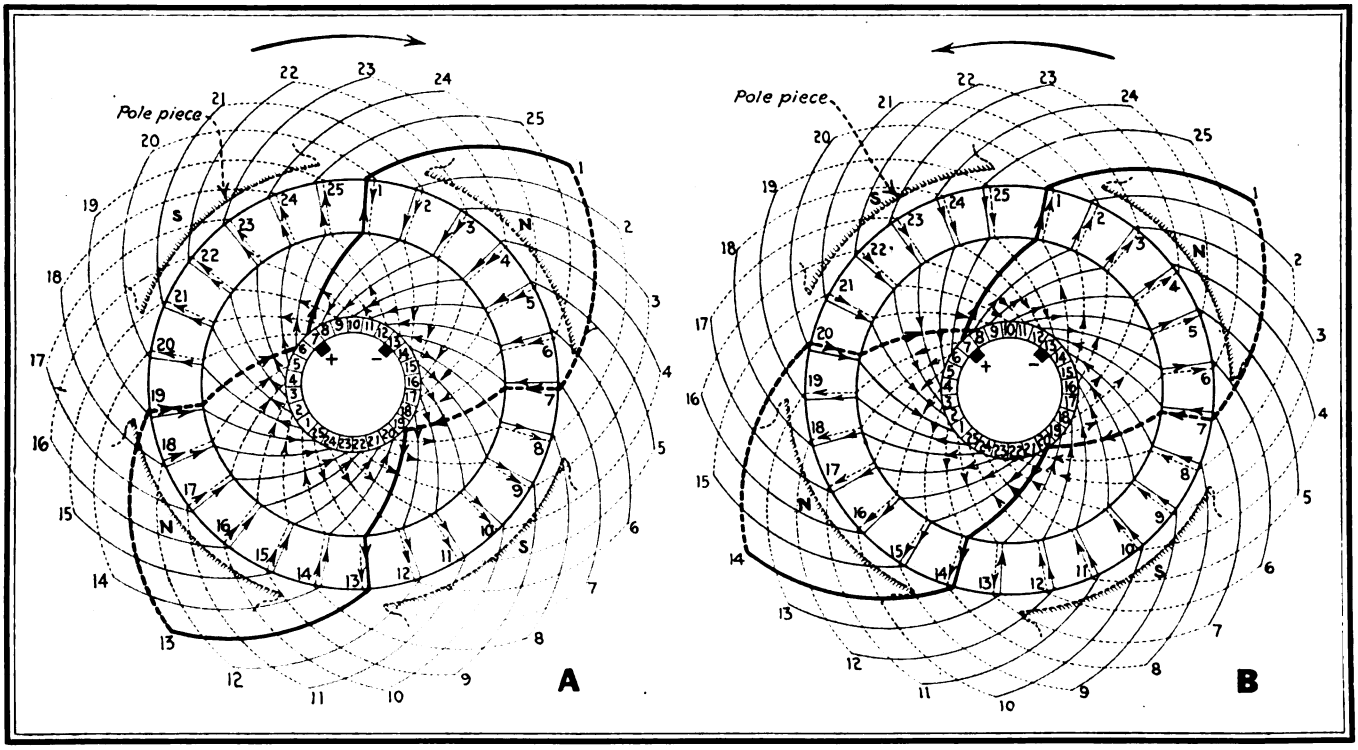
(2) With the coil pitch one and an even number, and an even number of coils per cell, the center line of the coil will fall on the center line of a tooth and bar.

(3) With the coil pitch one and an odd number as 1-and-9, 1-and-11, etc., and the coils per cell an odd number, the center line of the coil will fall on the center line of a slot and mica.

(4) With the coil pitch one and an odd number, and the coils per cell an even number, the center line of the coil will fall on the center line of a slot and bar.

Fig. 3—These diagrams show A, a four-pole, two-circuit, wave winding with retrogressive layout and connections and B, a four-pole, two-circuit, wave winding with progressive layout and connections.

By tracing through a series of coils in diagram *A*, it will be noticed that the series ends one bar behind the bar on which the series started, giving what is termed a retrogressive winding. On the other hand, each series of coils in diagram *B* ends one bar ahead of the bar on which that series started, thus giving a progressive winding.



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(5) With the coil pitch one and an odd number, the center line of the coil will fall on a slot, and with the coil pitch one and an even number the center line will fall on a tooth.

With the above rules in mind, slots *D*, *E*, *F*, of Fig 2 can be located as follows: Call slot *A*, No. 1 and express the coil pitch *S* in slots, as 1-and-10, or *S* equals 9. Then, when $(S+2)\div 2$ equals a whole number, this will be the number of slot *E*. For example, with a pitch of 1-and-13, *S* equals 12 and $(S+2)\div 2$ equals $14\div 2=7$, or *E* equals slot 7. When $(S+2)\div 2$ results in a fraction, the whole number will be slot *D* and by adding the fraction ½ to the answer obtained above, slot *F* will be located. For example, with a coil pitch of 1-and-12, *S* equals 11, and *D* equals $(11+2)\div 2$, or 6½. Slot *D* is then 6, and *F* equals 6½+½ or 7. The following formula may be used for locating bar *K*:

$K=Y-[(\text{coils per cell}\div 2)\times(\text{coil pitch}-2)]$, where *Y* equals the total number of bars. For example, if there are 28 slots and 84 bars, coil pitch 1-and-7, $K=84-[(3\div 2)\times(7-2)]=76.5$, or *K* equals 76. When *K* comes out a whole number and a fraction, drop the fraction and use the whole number.

The above rules cover the majority of cases of lap windings and the instructions given later will enable the reader to check and lay out any special winding.

Winding Rules That Apply to Wave Windings

There is a fundamental principle that applies to the number of bars that can be used in a wave winding: namely, the total number of bars for a single-series (wave) winding must satisfy the formula $L=(B\pm 1)\div P$, where *L* equals the lead pitch expressed in bars, as 49, 50, etc., *B* equals the total number of bars, and *P* equals one-half the number of poles. This formula requires that a group of coils connected in series, equal to one-half the total number of poles, shall encircle the armature, and that this series of coils must end either one bar ahead, or one bar behind the bar that the series started on. (See Figs. 3 *A* and 3 *B*.) Thus the number of bars for a four-pole winding must always be an odd number, or if an even number of bars is used, one or more bars must be connected by a long or short jumper to form a half-idle bar (as in Figs. 4 *A* and 4 *B*), to make the total number of bars satisfy the formula. On six-pole machines the number of bars can be odd or even, but each case must satisfy the formula. On eight-pole windings the number of bars must be odd, etc.

The above formula furnishes the basis for working out wave windings as applied to direct-current armatures. Details will, therefore, be given to describe its practical application. For a four-pole machine the formula can be changed to read, lead pitch equals $(B-1)\times 0.5$, for retrogressive windings, and to $(B+1)\times 0.5$ for progressive windings. From the above it follows (for any number of poles) that when the plus sign is used, the winding will be progressive. By this is meant that the series of coils will end one bar ahead of the bar that the series started on, as in Fig. 3 *B*. On the other hand, when the minus sign is used, the winding will be retrogressive or the series of coils will end up one bar behind the bar started on. (See Fig. 3 *A*.)

For example, consider a four-pole machine with 25 slots and 125 bars. Then *B* equals 125, *P* equals 2, and *L*, the lead pitch, can be $(125+1)\times 0.5$ equals 126×0.5, or 63, which gives 1-and-64 for a progressive winding. When the minus sign is used, $(125-1)\times 0.5$ equals 124×0.5, or 62, which gives 1-and-63 for a so-called retrogressive winding.

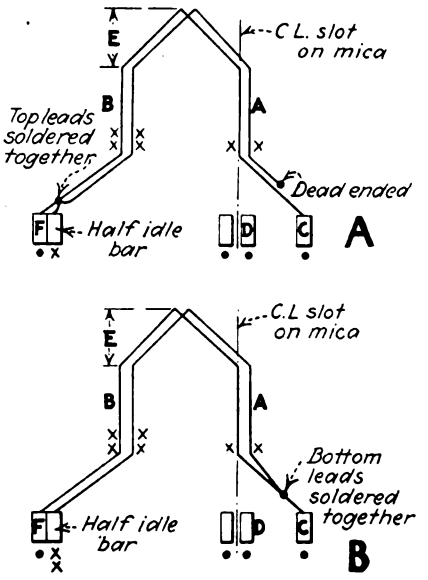


Fig. 4—Two methods of making a half-idle bar connection.

In diagram *A* two top leads are soldered together and two leads brought out from the junction to the two commutator bars, as shown. The bottom lead of the right-hand single coil is dead-ended. In diagram *B* the bottom lead of the right-hand single coil is soldered to the bottom lead of the second single coil. One lead from this junction is brought out to bar *C*, while the two top leads are brought out to two bars, as shown at the left.

This brings out an important feature of the wave winding on a four-pole machine; that is, when a given number of bars satisfies the above formula, then a retrogressive or progressive winding can be used as desired. This applies only to four-pole windings, however, since with six, eight, etc. poles, the type of winding depends upon whether one is to be added or subtracted from the given number of bars to make it close up. This is important because with a wave winding, changing from a retrogressive to a progressive winding, or vice versa, will reverse the direction of rotation in a motor and change the polarity of the brushes on a generator.

Figs. 3 *A* and 3 *B* are shown to illustrate this important fact. To simplify things, 25 bars and slots have been used. The coil pitch is 1-and-7 in both cases, and a left-hand winding is used. The pole-pieces for a four-pole machine are shown in dotted lines. With 25 bars and four poles, the lead pitch for a retrogressive winding should be $(25-1)\times 0.5=12$, or 1-and-13. The winding shown in Fig. 3 *A* is laid out with this lead pitch of 1-and-13. One series of coils is shown with heavy lines (coils *1* and *13*) the series starting on bar *7*, to slot *1*, slot *7*, to bar *19*, to top slot *13*, bottom slot *19*, to bar *6*, or one bar behind the one started on. Next, assume that this armature winding is used in a motor and that the brushes are in contact with bars *7* and *13*, as shown. With bar *7* in contact with a positive brush, the direction of current flow in the armature conductors will be indicated by the arrows in each slot. Slots *21* to *25*, show the arrows pointing away from the center of the diagram. This will cause the armature to rotate in a clockwise direction, as indicated by the larger arrow. Now consider Fig. 3 *B* which has the same number of slots and bars as was used in Fig. 3 *A*. But, Fig. 3 *B* uses the long lead pitch, or *L* equals $(25+1)\times 0.5=13$, or 1-and-14, which results in a progressive winding. The series of coils indicated by the heavy lines, starts on bar *7*, as in Fig. 3 *A*, goes to the top of slot *1*, to the bottom of slot *7*, to bar *20*, to top of slot *14*, to bottom of slot *20*, to bar *8*, or one bar ahead of the one started on. Then with the brushes in the same place and of the same polarity as in Fig. 3 *A*, the direction of the

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current in slots *21* to *25*, will be opposite to what it was in Fig. 3 *A*, and with the same field coil polarity, the armature in Fig. 3 *B* will rotate in a counter-clockwise direction as indicated by the large arrow.

The reason for this reversal can be understood if we start at bar *7* in Fig. 3 *A* and follow one path through the armature to the negative brush in contact with bar *13*, putting direction arrows in each slot as we pass through. Consider the top half of the coil in slot *1* as the starting point and dividing line; then the current path is, bar *7*, up slot *1*, down slot *7*, bar *19*, up slot *13*, down slot *19*, bar *6* and up slot *25*. Note that we now pass up through a slot to the left of the first slot passed through for the beginning of the second series. We continue down slot *6*, bar *18*, up slot *12*, down slot *18* to bar *5*, then up slot *24*, or we are picking up a slot to the left at the end of each series, until we finally end up on bar *13*. Next, compare Fig. 3 *A* with 3 *B*. Starting on bar *7*, we pass up through slot *1* as before and down slot *7*, to bar *20*, up slot *14*, down slot *20* to bar *8*. Note that we have advanced one bar and slot to the right with the pick-up of the second coil, and that from bar *8* we pass up through slot *2*, or to the right of slot *1*. This will continue until we reach bar *13*. Compare the current direction in slot *2* in both illustrations, Figs. 3 *A* and 3 *B*. It is the overlapping of the series that changes the current flow and from the above it is obvious that in changing from a progressive to a retrogressive winding or vice versa, regardless of the number of poles, the direction of rotation in a motor will be reversed, and in a generator the polarity of the brushes will be reversed.

What really happens in a generator, when the winding is changed, can be explained as follows: The direction of rotation is fixed and with a shunt- or compound-wound, self-excited generator, with long or short shunt connection, the field circuit forms a closed circuit regardless of whether the line switch is closed or open. Now, the field poles of any generator retain a certain amount of magnetism, or they act as permanent magnets, so that when the generator armature starts to revolve, and the field switch is closed, the armature conductors cut the lines of force due to the residual magnetism and a voltage is induced in the armature conductors, causing a current to flow around through the field coils and increase the field strength. This cycle keeps up until full-load voltage is reached. When the armature winding has been changed, the direction of current under any one pole will be the same, but the brush sign will be changed and when the generator is started, the first slight voltage generated due to residual magnetism will tend to reverse the field coil polarity and weaken the field; hence the generator will not be able to pick up. The only way to make the machine pick up would be to reverse the field connections which would necessitate flashing; that is, putting current through the fields from an outside source, to create a residual flux of the right polarity and enable the machine to pick up. Or the armature leads can be reversed and if caught in time, reversing the armature leads will in most cases eliminate the necessity of flashing the field. On the other hand, if the machine is separately excited it will pick up its voltage, but the busbar polarity will be reversed, which in a battery charging outfit would cause considerable trouble.

To point out some other effects of changing windings, Figs. 5 *A* to 5 *F* are shown.

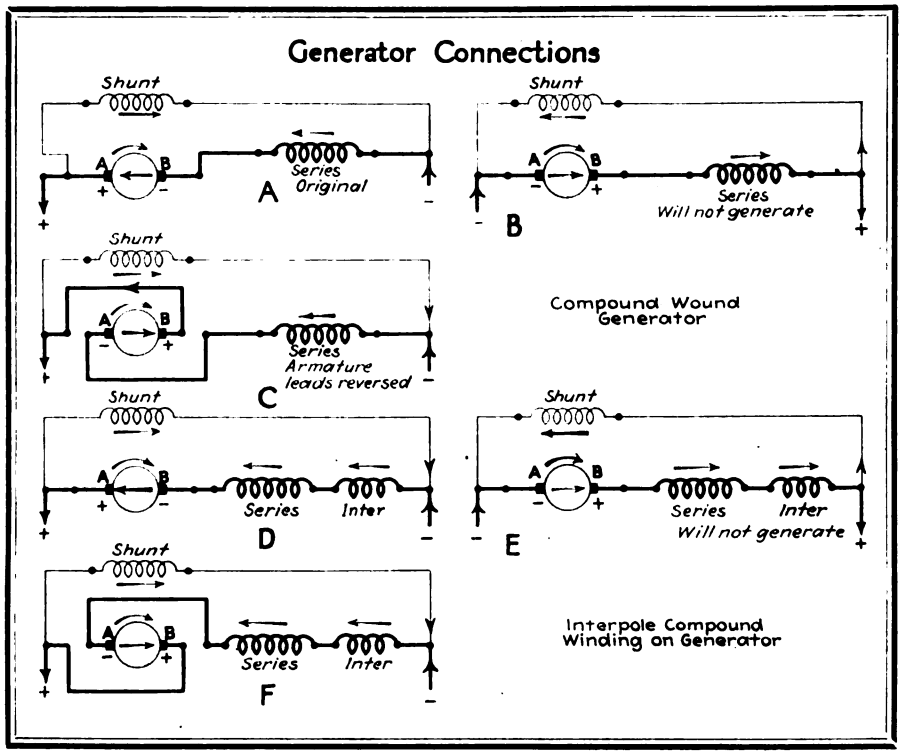
Fig. 5 *A* shows the armature and field circuit of a compound-wound generator. The directions of the arrows on the shunt and series fields are opposite, but this can be accepted as standard, as it makes the diagram straight lines. In a generator diagram, then, when the shunt and series arrows point in the opposite directions, we will call this standard. The direction of current through the armature is indicated by the arrow inside the circle, while the curved arrow indicates the direction of rotation. Next, consider Fig. 5 *B*, which shows the current flow in the same machine, with the armature winding changed. Note that brush *B* is positive, which changes the polarity of the shunt and series coils, but both coils still assist each other. The generator shown in Fig. 5 *B* will not pick up as already explained. Fig 5 *C* shows the simplest method of correcting the mistake. In this case the armature leads have been interchanged.

Fig. 5 *D* shows a compound-wound generator with interpoles. Note that the interpole coils are shown on the same side of the armature with the series coils, which results in a lower difference of potential between these two sets of coils, and reduces the chance of flashover between them. Fig. 5 *E* shows the same machine with the armature changed. This machine will not pick up until the connections are changed as in Fig. 5 *F*. Note that the series and interpole coils are handled as a unit.

Next, we will consider a motor.

(*Please turn to page 402*)

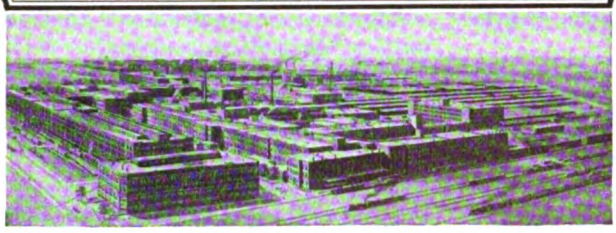
Fig. 5—These diagrams show correct and incorrect connections for compound-wound generators.



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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, August, 1925

Plant Savings Depend on Vision as Well as Volume

RECENTLY an executive in a small industrial plant lamented, during a plant inspection trip with one of the editors, the inability of a small plant to adopt money-saving ideas from a large one. The lack of vision of this plant executive was well illustrated by his actions on this trip. He was very much interested in the big savings made with a large crane, an extensive conveyor system, and other big units which were far beyond the capacity of his plant. On the other hand the type of tote boxes used and the methods of handling, piling and storing them, the inspection routine in connection with motors and other equipment, and the details of handling other problems common to his as well as practically all plants, were dismissed as too commonplace even to look at. As a result he did not carry away one worth-while idea.

This executive believes that savings and methods are inseparably connected with large, quantity production. A big volume of savings is, of course, related to quantity production, but the possibilities of making savings in industrial work are no more dependent upon volume than is the possession of a savings account at the bank dependent upon the amount of salary earned. Both depend upon the willingness to save and the ability to see opportunities for saving. The savings may be small, but they are possible.

What Happens When an Induction Motor Starts

WHEN an induction motor starts something happens besides the drawing of a heavy starting current. This is no news to electrical engineers, but it has taken a long time for them to find out and agree on just what it is that goes on in the windings of an induction motor during the starting period.

J. T. Rylander, at a recent convention of the A. I. E. E., has come forward and told us about at least three things that happen, as follows: (1) The windings separate between phases. (2) The windings move away from the rotor and toward the stator. (3) The top and bottom layers of coils draw together.

This is a most intelligent explanation of some of the mysterious grounds and short-circuits that develop in a winding and are, in most cases, laid at the door of some armature winder who got in a hurry and pounded too hard with his mallet and drift. The mallet and drift, when roughly handled, provide a sure way to start a weak spot in a winding when the slot space is crowded and wedges are used, but it is gratifying to know that at least one well-informed engineer is willing to admit that improper use of starting equipment is just as bad in its effect on the motor winding as the roughly-handled mallet and narrow drift.

Lest we be misunderstood, it is important to say here that Mr. Rylander in his A. I. E. E. discussion was attempting to prove that the windings of induction motors can be so braced and insulated as to stand the mechanical strains of even full-voltage starting. In this he went a long way, but we believe it will take a long time and be a hard job to make, at a reasonable cost, a large induction motor that will be free from operating troubles when used without a suitable starting device that will limit the current rush at starting and the mechanical strains on its windings. Motors are bought to use and not to repair, and any device that will safeguard continuous performance is cheap operating insurance against those who are careless in their installation and upkeep. Modern motor starting devices furnish this insurance at low cost when good judgment and not merely price govern their selection and manner of installation.

More Light May Be the Key to More Production

WHEN the days are long, as they are now, and a minimum of artificial illumination is required, it is an easy matter to overlook the important part which the lighting system will begin to play within a month or two from now. The fact that such an oversight may be more expensive and serious than might be thought, is brought out in the article by Roy Palmer, on page 363 of this issue.

In this article he points out the interesting relationship that has been found to exist between intensity of illumination and production output. In the investigations which have been conducted in various industrial plants, increases of production ranging from 8.5 to 35 per cent were found to be possible when the illumination was increased to the proper value. Although the cost of illumination naturally increases with the intensity, this increased cost amounted in every case to only a small percentage of the payroll. In other words, a considerable increase in production was left as clear profit, after the cost of the increased illumination had been deducted.

The slowing down of production which occurs in most industrial plants during the summer months affords a good opportunity to check up the lighting system and see what should be done to put it in such condition that it can efficiently render the service required. Perhaps only a thorough cleaning of lamps and reflectors and the replacement of burned-out or blackened lamps, will be necessary to put the system in proper condition. On the other hand, an investigation might show the

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need of a thorough revamping, in order to raise the level of illumination to its proper value.

In either case, the experience of many industrial plants shows that the returns will amply justify whatever expenditures are necessary.

Maintenance Today Will Save Repairs Tomorrow

TESTING important equipment so as to locate prospective failures should be the aim of every one responsible for maintenance work.

How this is being worked out at one plant may be of interest to others. As part of the regular maintenance work of a plant recently visited, the insulation resistance is measured on all vital or important motors and generators, at least once a month. These readings are recorded for comparison with readings taken later on.

The value of this practice was shown recently when the insulation resistance on the field of a synchronous motor began to fall below its usual value. It continued to get lower until a value of 600,000 ohms was reached, when an extensive investigation was decided upon. The individual coils on the poles were disconnected from each other and the trouble localized in one pole. The coil was removed from this pole and the insulation was found to be almost gone on the inside lower end.

If the machine had run much longer, undoubtedly a failure would have occurred, which would have interrupted production. As it was, the systematic tests gave warning of the approaching failure and permitted investigations and remedies to be applied on Sunday, when no production delay would occur, and there was time to do a good job.

This is just another example of how maintenance work can be made to yield big returns on the time and money spent on it. To paraphrase an old saying, a little bit of maintenance beforehand is generally worth a large amount of repair work—afterward.

What and Where Are Eye Hazards in Your Plant?

A REPORT which has recently been issued by The National Committee for the Prevention of Blindness, following an extensive study of eye hazards in industrial occupations, contains many statistics and facts that should be of interest to every plant executive. The toll which industry has taken in the way of injured or sightless eyes is shown by the following statement:

"Of the 100,000 blind persons in the United States approximately 15,000 are the industrial blind—persons who have lost their sight in the pursuit of industrial occupations. There is, in addition to the totally blind, a much larger number of men, women and children whose vision has been so impaired by the eye hazards of industry that they are handicapped throughout life. Both of these classes, the industrial blind and the workers whose vision has been seriously impaired by the hazards of other industrial environment, grow larger each year.

"The loss of 82 eyes in the presumably safe occupations of merchandising, farming, and textile manufacture, is further proof of the statement that serious eye accidents are likely to occur wherever men, women and children are employed. There is no such thing as a really non-hazardous occupation."

As an example of the important part that eye injuries play in the whole problem of industrial accidents the report cites the experience of a large shipbuilding company in whose dispensary 38 per cent of all injuries treated were eye injuries. More than 4,300 eye cases were treated in this company's dispensary in one year.

These facts would seem to constitute a severe indictment of industry, and serve to show that the prevention of eye injuries in industrial occupations is a problem that is worthy of, and should be given, the most serious attention. Carefully-kept records showing exactly where, how, when and why eye accidents occur will do much to show what changes should be made in equipment, methods, or processes in order to reduce the number of such accidents. Further, a careful study, from the standpoint of eye hazards, of the methods and equipment used in a plant may show where and how these hazards may be materially lessened.

Do Not Judge Suitability By the Price

BECAUSE a material is high priced does not necessarily mean that it is the most suitable for every industrial application. A case in point recently came to light in a large steel plant.

At this plant considerable bearing trouble was being experienced on certain equipment. Although the bearings which were originally furnished by the manufacturer of the equipment had shown satisfactory life, the bearing replacements made in the plant repair shop were not giving anywhere near satisfactory service.

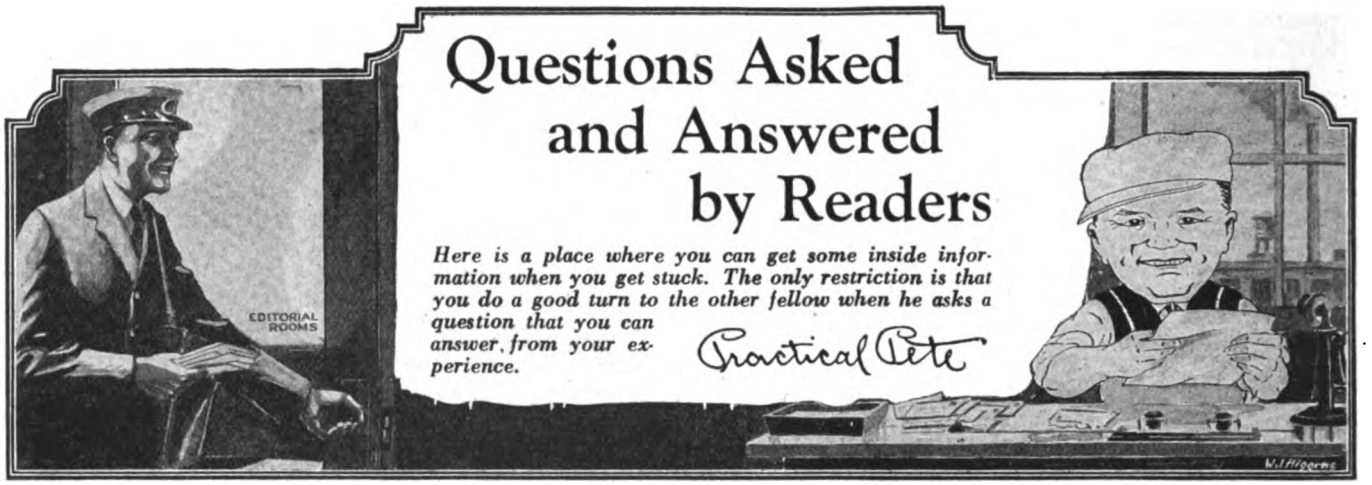
Investigation showed that the babbitt metal that was being used was not suited for the service conditions under which these bearings had to operate. It was a good babbitt metal, but was being incorrectly applied. Substitution of a suitable grade of babbitt metal, which was melted and poured at the proper temperature, gave more satisfactory results. Incidentally, the correct grade of babbitt for this application cost less than one-third as much as that which had been formerly used.

This discovery stimulated other bearing investigations at this plant. It was found that everybody on the maintenance force was babbitting bearings. Since none of them knew much about babbitting, the results were poor indeed. Also, since more than one kind of babbitt is required for the various machines in the plant, and each of these babbitts has a different pouring temperature, it was somewhat a matter of chance as to whether the metal was poured at the right temperature.

The first step taken to correct these bearing troubles was to place all of the bearing work under one man, who either did the work himself or directly supervised it. The second step was the purchase of an electrically-heated babbitt pot with automatic temperature control, thereby insuring the correct pouring temperature. The third step was in taking additional pains in the selection of bearing metals that are particularly adapted to the service conditions. According to the superintendent of that plant, the results obtained have justified the additional expense involved many times over.

If you are looking for a place to cut maintenance costs it may be that your bearing troubles will stand a similar investigation.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer, from your experience.

Practical Pete

Who Can Answer These?

Operating A.C. Demagnetiser on Direct Current.—Will some reader please tell me of a cheap and simple way of changing a 110-volt a.c. demagnetizer so that it can be operated on direct current at the same voltage?
Norristown, Pa. C. D. H.

* * * *

Changing D.C. Fan Motors for Operation on Alternating Current.—Our plant has recently been changed over from direct current to alternating current, 110 volts, 60 cycles, and I should like to know if there is any way of changing Westinghouse, 9-in. and 16-in. d.c. fans to operate on alternating current, as I do not wish to discard them if I can help it. One of these fans has the following nameplate data: Serial No. 1883821, style No. 321339, d.c. 100-125 volts. I shall appreciate your help.
Philadelphia, Pa. E. G. R.

* * * *

Method of Cleaning Skylights and Windows.—In our plant we have a serious problem in connection with the cleaning of skylights, transoms in monitor roofs and above the first floor, large windows with steel sash. I wish some readers would tell me what solutions they use for such cleaning, and describe any easily-constructed scaffolding or other method which they use to get to this large area of glass. This has been a very expensive and unsatisfactory procedure with us so far and I would like to know what others do.
Indianapolis, Ind. J. F. H.

* * * *

Contactors Will Not Close on Low Voltage.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?
Omaha, Neb. M. P.

* * * *

Trouble With Rewound Transformers.—I am having trouble with rewound G. E., type H. 5-kva., 2,300/220/110-volt transformers burning out within a few days after they have been placed in service. They break down between turns in the same layer, but do not break down to ground. In the primary I use No. 18 B. & S. gage single-cotton-enameled wire, impregnated with Westinghouse Amber baking varnish. I am using the same wire and varnish on motors with good results, but am wondering if I should use double-cotton-covered wire and some other varnish for the transformers. Do the transil oil and varnish combine to attack the enamel? These transformers are given a double voltage test for one hour before leaving the shop.
Ware Shoals, S. C. J. C.

Operating Two Slip-Ring Motors in Cascade.—I shall be very grateful if some reader will answer the following questions for me: (1) Will two slip-ring motors of the same make and type operate satisfactorily when connected in cascade and installed on the opposite ends of a turntable to drive separate tractors? (2) Will there be any difference in the speed of the two motors? If so, what will it amount to? (3) Can these motors be operated from one controller? If so, can they be used for reversing service when operated from one controller? (4) Must the shafts of the motors be rigidly coupled together?
Washington, Ind. C. L. O.

* * * *

Stopping Breakage of Gears.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. Would a coupling having shear pins do the trick? How could I make such a coupling?
Tulsa, Okla. L. A. N.

Answers Received To Questions Asked

Emergency Excitation for Generators—For exciting our generators we have one motor-driven exciter which is normally in use. After the station has been completely shut down, we have one steam-turbine-driven exciter which is used for starting. Suppose that when we attempt to start up, the steam-driven exciter should break down. How could we excite our field? Could it be done by using several automobile storage batteries in series? For exciting our generator at no load, we require 60 amp. at 65 volts and it would be necessary for this supply to be on for approximately 10 min. Would it be practicable to use eleven 6-volt storage batteries in series for supplying this excitation? If so, what capacity should the storage batteries have? I shall appreciate any information that readers can give me on this problem.
Medicine Hat, Alta., Can. E. R. S.

Answering E. R. S. in the July issue, the fields can be excited only by the use of another exciter or an emergency battery. In one instance that came up in my experience, only a motor-driven exciter was used and an outside service was depended upon for energy when the station was completely shut down. Provision was made for an interruption in the outside service by putting an extension on the shaft of each generator unit, to which a small generator could be belted. A pulley was provided to fit the generator shaft extension. The small generator was mounted on a truck so that it could readily be moved about, and served its purpose very well. It is assumed that in E. R. S.'s case there are no electrically-operated oil circuit breakers in the station, requiring a battery which might be used as a source of current in emergency.

The fields could be excited by the use of a number of automobile batteries connected in series, but while it is practicable to do so this could not be recommended as a very satisfactory method. Whether the automobile batteries would handle a discharge rate of 60 amp. for ten minutes could be determined only by trying it, or by consulting the manufacturer of the batteries. Although many automobiles require between 50 and 100 amp. or more for starting the engine the duration of the discharge rarely exceeds one minute and is usually much less.

It is assumed, of course, that it is not desired to have a small gas- or gasoline-driven set, similar to the Delco or Kohler, available for this service. However, the ease of providing a shaft extension on which a pulley can be placed for driving the low-capacity exciter, as previously described, is, I believe, the simplest and most practical solution of this problem.

C. OTTO VON DANNENBERG.
Designing Engineer,
Porter & Sanderson,
New York, N. Y.

* * * *

Trolley Wire Supports for Monorail Crane—I have a monorail crane running on an I-beam, which has to travel around two rather sharp bends, and wish that someone would give me his experience as to the best way of installing and supporting the two trolley wires that feed this crane. How should I support the wires where they go around the bends?
Barre, Vt. C. G.

In reply to the question by C. G. in the May issue, the use of trolley wires around curves on crane tracks is very troublesome. We have found that the tee bar system is by far the best to use under these conditions.

If 1¼-in. tee bar is used it can be bent cold to fit almost any bend or angle that may be required. The tee bars should be held in place by

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1½-in. by ½-in. angles clamped to the top of the I-beam.

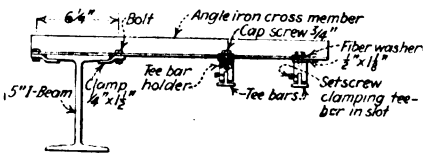
At the proper distance apart, equal to the distance between the collector shoes on the hoist, two ¾-in. holes should be drilled in each angle. Into these holes a piece of fiber tubing ¾ in. in diameter with a ½-in. hole should be placed, and cut off flush with both sides of the angle. On the same side of the angle, two 7/16-in. holes should be drilled for supporting the clamps by which the angle cross-member is fastened to the I-beam. For a 5-in. beam we drill these holes 6¼ in. apart. For the clamps we use a piece of steel ¼ in. thick and 1½ in. long. By placing a ¼-in. offset in this piece, drilling a 7/16-in. hole in the end and placing this clamp against the underside of the top of the I-beam, and bolting to the crossarm, a very rugged support can be made.

For the tee bar holder a piece of steel 1 in. square and 1½ in. long is used; a hole is drilled in one end and tapped for a ½-in. capscrew. In the other end a slot is cut ¼ in. wide and ¾ in. deep. In one side, opposite the slot, a hole is drilled and tapped for a ⅜-in. setscrew for holding the tee bar.

When mounting the tee bar support to the crossarm a fiber washer ⅛ in. thick and 1⅛ in. in diameter with a ½-in. hole in the center, is placed between the tee bar support and the crossarm. Another washer of the same size is placed on top of the angle-iron crossarm. A ½-in. capscrew with a flat iron washer is then screwed through the washers, bushing, and into the tee bar support; this prevents any danger of grounding. This method of supporting tee bars indoors has proven a success with us; for outdoor service we use a porcelain support in the same way.

For collecting the power from the tee bar we use a shoe made by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. These shoes are designed to take care of any uneven joints and also any side motion caused by swinging loads, and to keep a constant pressure against the tee bar. On our hoists which operate on very sharp curves we use a wider shoe; this gives us greater contact when the hoist first starts to make the curve.

The operation of a medium-sized hoist, with a capacity ranging from 2 to 6 tons, operated on curved I-beams continuously, means a very heavy maintenance cost, owing to the fact that as soon as the loaded hoist enters on the curve it must change the direction of the load. This causes a side strain on the hoist, causing the wheels to bind against one side of the I-beam. In a short time this cuts the flange of the hoist wheels to such an extent that if the wheels are not changed at regular intervals climbing of the wheels on the I-beams will be experienced on the curves, thereby permitting the opposite wheels to wedge against the I-beam flange and stick, making it necessary to rock the hoist back and forth on the beam. At the same time, the I-beam cuts very fast, shortening the life of new wheels and in due time replacing of the beam is required, which is a costly operation.



This shows how the tee bars are supported from a crossarm mounted on top of the I-beam.

In view of this we have adopted the plan of fastening a 16-lb. rail to the lower flange of the I-beam by means of the Shepard rail clamp, which does not require any drilling of the I-beam for supporting the rail. When replacements are necessary it is much cheaper to change a rail than a curved I-beam. Also, as the rail has a much wider surface bearing against the flange of the wheel on curves, the life of the wheel is prolonged.

At present we are operating several hoists on the above system 24 hr. a day, under severe duty, including side lifts and overloads. The delays and repairs are very low, considering the service we get from the hoists.

I hope that the facts and suggestions given above will be of help to C. G.

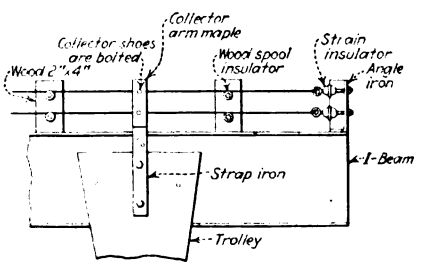
Chief Electrician, N. H. CASE.
Wyckoff Drawn Steel Co.,
Ambridge, Pa.

* * * *

In reply to the question by C. G. in the May issue, I would like to submit the following:

A few months ago I had occasion to install several Morris cranes of the monorail type which were equipped with Twin Flex cable having rubber insulation about 1 in. in diameter. This cable was looped from convenient switches up to the crane. This we found satisfactory, where the distance of travel was short. In one particular case, however, the crane had to travel a distance of about 200 ft. Such a length of cable was exceedingly cumbersome and always got in the way of things, twisting around workmen and trucks and breaking off at the motor connection, thus causing considerable delay and trouble.

To overcome this difficulty, we adopted a trolley wire system for this 200-ft. stretch of travel. At each end of the travel of the crane a support was erected at right angles to the crane travel. These supports were made of ½-in. by 6-in. angles. They were attached to the I-beam which carried the crane. On the side of the angle, which is at a right angle to the I-beam, two holes were drilled, one above the other, which hold the strain insulators to which the trolley wires are attached. The trolley wires are of No. 4 hard-drawn copper. These wires were stretched between the two angles in such a position that they would be in line with the collector shoes on the trolley. To support the trolley wires and prevent them from sagging, wood insulators were placed beneath the trolley wires at convenient points. These wood insulators were shaped somewhat like a spool with flanges 2 in. in diameter, body 1½ in. in diameter and an overall length of 6 in. A hole suitable for a ½-in. bolt was drilled through the center of the insulator and countersunk at one end to take the head of the bolt. The wood insulators were fastened by means of long bolts to the uprights which are attached to the top of the I-beam, as is shown in the accompanying drawing.



Method of supporting trolley wire system for monorail-type crane.

At one part of the travel the I-beam had to be bent to meet the conditions under which it had to operate. This bend was about 6 in., running in this position for 15 ft., and reverting back to the same position. This difficulty was overcome by putting in longer bolts and placing wood fillers of the required length at the back of the insulator spools in that section.

The collector support is bolted to the trolley. The bottom part of the support is made of 2½-in. by ⅝-in. flat iron. To the top part of this flat iron is bolted a piece of maple 2½ in. wide by 1¼ in. thick and of the required length to suit the conditions. Two holes were drilled through the top part of the maple piece for the bolts carrying the collector shoes. The collector shoes have a deep groove which holds the trolley wires in position at all times. These grooves are placed slightly higher than the wood insulators, so that when the shoes pass the wood insulators they lift the wire above the insulators, permitting the shoes to clear the insulator. After the shoe has passed over the wood insulator, the wire settles back on the insulator. The bolts to which the collector shoes are attached have about 5 in. of thread so as to allow for adjusting the shoes to the proper position over the spools and for attaching the cables running to the hoist motor. The wooden part of the collector arm support is reinforced by a piece of ⅛-in. by 1-in. hoop iron over the top and extending about half-way down the side. The wood spool insulators are mounted on pieces of 2-in. by 4-in. wood which are bolted to the top of the I-beam and are placed at intervals of about 15 ft.

This trolley wire transmission eliminated all of the trouble that we had been having. It has been in successful operation for 12 months and there has not been a single delay on any of the cranes on which it was installed.

This performance must be considered exceptionally good when we consider the fact that the cranes are doing very heavy duty in the handling of car trucks, material and heavy dies for the hydraulic presses, and the like.

LACHLAN A. MCEWAN.
Maintenance Electrician,
Car Shops, Canadian National Railways,
Montreal, Can.

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Answering C. G.'s question in the May issue, I use No. 8 trolley wire on the straight runs and ¼-in. by 1½-in. flat iron bent to the curvature of the I-beam on all curves and turns. The flat iron is supported on standard I-beam trolley wire supports. I believe that the use of this arrangement would satisfactorily overcome C. G.'s troubles.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

* * * *

Replying to C. G. in the May issue, he will have to use a good many supports if he adheres to his policy of suspending trolley wires around sharp bends on a monorail crane system.

In place of trolley wire, I would suggest that he use at these bends and for 10 ft. or so on each side of them, ⅜- or ½- by 1½-in. iron flats, as they are called hereabouts. These are just flat iron ribbons and should be bent as desired and mounted edgewise on regular clamp-type insulators which, in turn, should be bolted to angle irons and the latter bolted or clamped to the top of the I-beam.

If preferred, flat copper strips could be used, although this is not necessary. In any case, where the strips and wire meet the strip should be cut back for a short distance in order that the wire may be brazed to the strip and then finished off, so that a smooth surface will be presented to the trolley wheel or collector.

Various schemes involving the use of clamps and other devices could be used to overcome the trouble C. G. describes, but I believe that the method outlined above is hard to beat, from the standpoints of simplicity and service.

Rome, N. Y. A. FIESS.

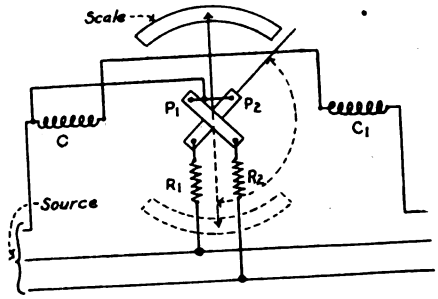
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Connecting Three-Phase Power Factor Meter—I should like to obtain the following information from some of the readers of INDUSTRIAL ENGINEER. (1) How may a three-phase power factor meter of General Electric make, be connected up for correct operation on either leading or lagging current when all of the polarity marks have been obliterated? (2) How may the circuits of the above meter be tested for continuity and zero setting of the pointer when it has been moved on the revolving shaft which supports it? (3) What would cause a shunt generator driven by an induction motor to build up slowly at the commutator and develop destructive arcing at the brushes after the load has been removed? What would be the remedy for such a condition? The armature is a single, parallel winding.

Saskatoon, Sask., Can. F. N. G.

In reply to the question by F. N. G. in a recent issue, the accompanying sketch shows the connection for a three phase instrument used on a balanced system.

C and C_1 are current coils in series on one leg of the system. P_1 and P_2 are potential coils connected across the other two legs of the line through the non-inductive resistance R_1 and R_2. In making the connections and checking for their correctness, the power factor must be known. If the needle drops to the bottom or dotted line scale, reverse the series connection. If the power factor is unity and the pointer takes a position to the right or to the left of center, reverse the potential leads. The circuits of the instrument



Internal and external connections of three-phase power factor meter.

may be tested for continuity with a lamp in series on a 110-volt circuit. If the pointer is loose or has been moved, connect the instrument to a circuit of 100 per cent power factor and place the pointer opposite the unity mark on the scale.

The character and range of the scale can also be changed by varying the angle between the potential coils.

With regard to the trouble which you are experiencing with a d. c. generator, the brushes are probably not set correctly in relation to the neutral point. Try changing the brushes either ahead or back a little at a time and see if it helps the sparking.

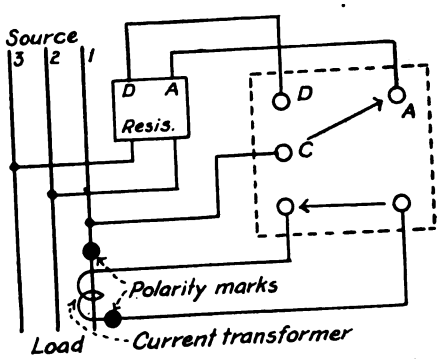
Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Referring to F. N. G.'s question in a late issue, (1) from the diagram it will be noted that the current from the generator is brought in at the right hand of the instrument when seen from the rear of the board. Should the connection be wrong the pointer will ride on one side of the scale in trying to turn 180 deg., and can be changed. If the pointer swings to the wrong side of the scale the potential leads should be interchanged between the resistor and the meter.

To check the connections of the meter short-circuit the current leads, at which time the pointer should go to the lag side of the scale regardless of whether the meter is indicating leading or lagging power factor.

(2) Unless one is thoroughly acquainted with the repair and operation of such a meter he should not attempt such repairs. It is much cheaper and better all around to have such work done at the factory by skilled operators.



Connection diagram for type H-2 power factor meter for circuits carrying 200 amp. or more.

(3) A weak field is apparently the cause of the generator trouble; I would also suggest that attention be given to the brush settings. Check the brush alignment and setting very carefully.

West Allis, Wis. EDWARD JAMES.

* * * *

How Long Will It Take to Erect These Towers?—I shall appreciate it very much if some of the readers of INDUSTRIAL ENGINEER can give me the amount of time in man-hours required to erect five steel transmission towers, 9 ft. by 15 ft. at the base and 60 ft. high. I should also like to know the time required to string three No. 3/0 stranded copper cables and one overhead ground wire a distance of 2,000 ft.

Appleton, Wis. M. P.

Answering M. P. in a recent issue, the question is rather indefinite as it gives no details as to the nature of the ground, present location of towers, whether the towers are already fabricated, whether foundations are already in, voltage, type of insulators, and so on. All of these points and many others would affect the cost of erecting the towers and putting the line in commission. Another point to consider is the previous experience of the erection gang in similar work, and the kinds of tools and equipment available. The erection of 2,000 ft. of line is quite different from erecting a line several miles long where the crew, even if they are comparatively inexperienced to begin with, will gain considerable proficiency in the work before many miles have been covered.

The best criterion for the cost of a job of this kind is reliable cost data secured from similar jobs. I have some figures covering the cost of a transmission line recently erected in the Middle West where unit labor cost would be the same as in M. P.'s territory. This was a 132-kv. line about 40 miles long. Double-circuit steel towers were used, having the approximate dimensions given by M. P. One circuit only was installed, using No. 3/0 steel-reinforced, aluminum conductor. The towers were assembled on the ground in a horizontal position and erected by means of a gin pole, block and tackle and a 2-ton tractor. A summary of the labor cost per mile of line, exclusive of trucks, freight, board, lodging, testing, tools, damages and miscellaneous was as follows:

(*a*)	Clearing	$ 244.00
(*b*)	Foundation	1,181.00
(*c*)	Assembling towers	311.00
(*d*)	Erecting towers	165.00
(*e*)	Stringing wire	130.00
(*f*)	Unloading and hauling	80.00
(*g*)	Engineering and supervision	240.00
	Total	$2,351.00

All of the above items, and especially item (*b*) were heavy because of the swampy nature of the ground. At this same rate a 2,000-ft. line would cost about $900 to put up, but it must be remembered that a small job cannot, as a rule, be handled as cheaply as a large one, on which everything is well organized.

In several other similar jobs the cost of erecting towers has gone as low as $95 per mile and from that

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on up to $165, as given above. The labor cost of stringing wire has been found, under favorable conditions in this class of work, to go as low as $40 per mile of conductor, or $120 per mile of three-phase line. Under unfavorable conditions, it may go as high as $80 per mile of conductor.

Another example may be given of a 66-kv. line, 33 miles long, using steel poles 3 ft. 6 in. square at the base and 60 ft. high, carrying two No. 1/0 stranded copper circuits on suspension insulators. These poles were considerably smaller than those used in the first example. The labor cost per mile of line in open, level country with 500- to 700-ft. spans was as follows:

(*a*)	Digging holes and placing foundations	$212.00
(*b*)	Distributing material	77.60
(*c*)	Bolting up and erecting poles	99.20
(*d*)	Stringing wire	141.20
(*e*)	Miscellaneous	44.80
	Total	$574.80

These two examples probably represent maximum and minimum cost for jobs of this character. Cost data from any one job should not be applied indiscriminately to any other job unless all governing factors are identical in all respects. Of course, this condition never exists in practice; so the best M. P. can do is to study the above and similar data and apply them to his job.

Fort Worden, Wash. E. I. PEASE.

* * * *

Replacing Motors When Trouble Develops—When armature or other troubles develop in a motor, should a new armature be put in or other repairs made, right on the job? Or is it better to replace the entire motor with a spare and send the damaged motor to the repair shop? This question has come up several times in our plant and I should like to know the practice followed by other readers.

Pittsburgh, Pa. E. W. D.

Answering E. W. D. in the April issue, it is always better to take out the entire motor and put in a spare one, if a spare is available. However, unless there are a large number of duplicate motors in the plant, it would be a rather expensive proposition to keep an extra motor for every machine. Also, since a large proportion of the trouble on d. c. motors is in the armature, it is usually necessary to keep only a spare armature in stock. On the other hand, an outside repair shop always likes to have the whole machine, so that they can give the rewound armature a thorough testing out.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

E. W. D. asked an interesting question in the April issue. I would not advise sending an armature or complete motor to the repair shop for every little trouble that comes along. Many armature troubles, such as grounded V-rings, shorted coils, open circuits and the like can often be cleared up on the spot at a real saving in time and money.

For my part I do not believe it advisable to replace a motor so long as it can be kept running. If E. W. D. has many motors, he will find it worth while to have these little jobs taken care of whenever possible right on the job. M. V. MILLER.

Service Dept.,
Westinghouse Electric & Mfg. Co.,
Indianapolis, Ind.

* * * *

E. W. D., whose question appeared in the April issue, will find a very good answer in the form of an editorial on page 189 of that issue.

Outside of large installations or minor breakdowns, repairs should not be made in the field if they can possibly be avoided. If a motor or any piece of apparatus is so important that its service is absolutely necessary for the welfare of an industrial plant, continual operation is more easily insured by a spare unit than by any form of repair that can be made in the field, field shop, or service station. When a breakdown occurs less experienced men can, at less expense, replace the damaged job and leave the damage to be repaired by more intelligent personnel.

Furthermore, standardization of equipment means less overhead in maintaining good service, a point that many industrial firms overlook in purchasing equipment. I recall one firm that had the greatest variety of electrical equipment that I ever saw. There was available every kind of motor, control apparatus, transformer, and auxiliary that I ever saw in one place. You can imagine the subsequent upkeep cost in this establishment.

West Allis, Wis. EDWARD JAMES.

* * * *

Replying to E. W. D.'s question in the April issue, the general trend of practice at the present time is to change armatures or do what repair work is necessary in the field. With a little forethought and system this work can be done with very little loss of time.

However, it stands to reason that a first-class job of repairing cannot be made in the field, as in most cases time is limited and facilities may be lacking. Therefore, I believe that in the case of d. c. motors, especially crane motors, the ideal practice would be to change the entire motor. Then they could be taken to the shop and thoroughly overhauled, which cannot fail to result in increased efficiency and greater length of service.

In plants where the equipment is standardized, this procedure would be entirely practicable and still not involve a big financial outlay in duplicate motors.

Existing conditions are a big factor, of course, in determining just what should be done in this particular phase of industrial maintenance.

JOHN W. CUBBAGE.

Standard Tin Plate Co.,
Canonsburg, Pa.

* * * *

In answer to E. W. D.'s question in the April issue, I would like to state that it depends a great deal on how serious the repair is, on the service which the motor renders, its importance and its size, also, whether the repair shop belongs to the company or to a contractor. It is considered good practice in steel mills and foundries to keep spare motors for important machines, such as cranes and machinery handling hot metal. These spares are kept in the field, where the motor inspector can quickly substitute them for defective motors. In some cases, a whole crane is available as a spare. The reasons for this are obvious: the cost of the motor is insignificant compared with the value of a large ladle of metal or a cupola full of molten pig iron. Also, the labor cost of dropping bottom on a cupola is a large sum compared with the cost of an ordinary motor repair. Other reasons for having spare motors are that motors repaired in the shop are more perfect and reliable, because the shop men have more time and facilities for doing a more thorough job, and they are generally paid a higher salary and are expected to do better work than field repair men.

If the repair man is an expert judge of motor troubles, he can probably make a temporary repair on a motor that has a slight defect, and if a shutdown of an hour or so does not matter, he can put in new bearings, or cut out a coil in a motor of average size. Of course, the necessary repairs could be made under almost any condition and anywhere within reason if the necessary mechanics are available. If the repair shop belongs to the company and the motor is not too large it is probably the best practice to have complete spare motors for the more important drives. The transportation facilities available for taking motors to the repair shop will limit the size of motors that can be handled in the shop.

If a motor is large, say, 500 hp. or over, the cost of a complete spare motor would be prohibitive, even if the plant otherwise had to be shut down a day or so while repairs were being made. Also, in the case of large hoist motors at mines, it would be cheaper to shut down the mines for a week or so to rewind the motor. In this case, especially, the cost of transporting the motor and moving it into and out of the hoisting house would increase the repair cost. Also, as an illustration, take the case of a large pump motor several thousand feet inside of a mine. In this case, it would be cheaper to rewind the motor right on the job.

Acmar, Ala. GRADY H. EMERSON.

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Calculating Starting Resistance for D.C. Motors—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?

Albert, W. Va. F. H.

Answering the question asked by F. H. in a recent issue, the object of starting resistance is to limit the current through the motor armature during the period of starting; that is, until the armature attains a speed high enough to induce a counter-emf. sufficient to check an excessive flow of current. Ohm's law may be used to determine the amount of excess current in amperes that would flow before the armature began to turn, if there were

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no starting resistance. Suppose for example that an armature has a resistance of 1 ohm and 110 volts are impressed on it; then by Ohm's law $I=E\div R$, or $I=110\div 1=110$ amp.

If there were no starting resistance 110 amp. would flow through the motor armature just before it began to turn. Note that the above calculation applies specifically to shunt-wound motors. If the motor were series- or compound-wound, the resistance of the series field would also have to be considered.

To determine by Ohm's law the amount of starting resistance in the case of a series motor, assume that the nameplate current of the motor is 10 amp. As this is a series motor the current through both armature and field will be the same and the armature can safely carry away a current of 10 amp. Then $R=110\div 10=11$ ohms, which is the total resistance required. To obtain the resistance required in the starting box, subtract from this total the series field resistance plus the armature resistance. Suppose these amount to 0.5 ohm plus 1 ohm or a total of 1.5 ohms. Then, 11 ohms—1.5 ohms=9.5 ohms, which is the required starting resistance.

In the case of a shunt motor the procedure is the same except that the current through the shunt field must be subtracted from the rated current in order to obtain the current through the armature and, of course, there is no series field resistance to be considered.

With a compound-wound motor, proceed as in the case of a shunt motor except that in order to obtain the starting resistance the resistance of the series field must be added to the armature resistance and the resistance of the two subtracted from the total resistance obtained by Ohm's law.

As the speed of the motor increases the counter-emf. tends to reduce or offset the applied voltage, so that less current will flow through the motor. Therefore, in order to allow sufficient current flow to produce the torque needed, the resistance must be reduced. Starting boxes are, therefore, made so that the amount of resistance in circuit can be reduced in a number of steps.

In the foregoing, the full-load current has been used in the formula, but it is a well-known fact that motors will carry a greater current for a short time, usually 125 per cent or more of the nameplate current rating, without injury. Because of this, if the motor must start under heavy load it may be necessary to allow 125 per cent or 150 per cent of the rated current to flow during the starting period, instead of the rated current.

A starting compensator is composed of one or more autotransformers. An autotransformer has but one winding which must serve for both primary and secondary windings. Any desired voltage up to the impressed voltage may be obtained by taking off taps at the proper point from the winding. Suppose, for example, that the supply voltage is 220 and we have a transformer coil of 144 turns with a 50 per cent tap taken off in the center. This 50 per cent tap includes one-half of the primary turns, or $144\div 2=72$ turns and the voltage across this tap will be one-half of the impressed voltage or 110 volts. The voltage across any tap is always the same percentage of the supply or primary voltage as the turns included by the taps are of the total primary turns.

Concord, Mass. DONALD FERGUSON.

* * * *

Answering F. H. in a recent issue, the method of calculating the resistance for starting direct-current motors is based entirely upon Ohm's law. It is common practice to limit the initial rush of current admitted to the motor to full-load value, and this determines the total resistance of the rheostat. This resistance can be easily determined by means of Ohm's law, $R=E\div I$, wherein R is the sum of the internal resistances of the motor and controller or rheostat, E is the line voltage and I is the full-load current of the motor. From this, it will be seen that the stand-still resistance of the motor from terminal to terminal plus that of the controller must be known or at least approximated in each particular case.

Having determined the total resistance required for starting and the frequency of starting, the designer is prepared to go further into details and decide upon the number of steps required and the proportion of the resistance in each step. The accompanying table gives the usual value for the resistance in each step and the per cent of full-load current which the resistance for each step should be able to carry continuously with a temperature rise not to exceed, say, 250 deg. C. This table is based on a current flow of 100 per cent of full-load amperes on the first step, for light intermittent starting duty, that is, one minute starting out of four.

The foregoing discussion deals only with the calculation of the resistance to be used and does not touch on the design of the resistance as regards heat dissipation. In a starting rheostat large quantities of heat are generated during the short period of starting, as the energy in the rheostat at that time is equivalent to the full, and often the overload, rating of the motor. In laying out the starting rheostat and in determining the size required it is helpful to calculate the total heat over a cycle of operations. A rheostat is assumed to be laid out according to the A. I. E. E. test specifications, or some other definite cycle, and the total heat generated during a given period can, therefore, be determined. If it is assumed that radiation is practically constant during the whole period of operation, the rate of radiation required to take care of all the heat generated can then be found and the size of resistor necessary determined approximately from a knowledge of continuous-capacity rheostats. For a short discussion of the calculations involved in the design of resistance starters, I would suggest that F. H. see paragraph 431, section 15, 4th edition of Standard Handbook for Electrical Engineers, or consult Pender's Handbook for Electrical Engineers, 1st edition, page 1369.

(2) Induction starters for polyphase motors are simply auto-transformers with a switching device for connecting the primary or stator winding first across reduced potential obtained from the starting transformer and then directly to the line. In large sizes these starters are usually arranged to operate in three or more steps, thus reducing the starting current surges. For medium-size motors they are generally designed to give one starting voltage

Per cent of total resistance and carrying capacity of each step of starting rheostat for d. c. motor.

Total Number of Steps		Percentages For Each Step								
		1	2	3	4	5	6	7	8	9
1	R	100								
	A	40								
2	R	80	20	R-Percent of total ohms						
	A	37	75	A-Percent of full-load amperes at continuous rating						
3	R	65	25	10						
	A	37	60	70						
4	R	49	27	15	9					
	A	37	53	59	64					
5	R	43	26	16	9	6				
	A	37	48	52	57	60				
6	R	38	25	16	10	7	4			
	A	37	47	50	53	57	59			
7	R	34	23	16	11	7	5	4		
	A	37	45	48	50	53	55	58		
8	R	31	22	15	11	8	6	4	3	
	A	37	44	46	48	50	53	55	57	
9	R	28	21	15	11	8	6	5	4	2
	A	37	42	43	45	48	50	52	54	56

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ranging from 40 to 80 per cent of line potential; the motor is then thrown across the line. The starting voltage to be used will vary with the size of the motor, the resistance of its rotor, the starting torque required, etc.

Auto-transformers for starting induction motors are provided with taps permitting the choice of any one of several voltages. They are, however, designed for starting service only and are not intended to be left permanently in circuit. The taps usually provided give 50, 65 and 80 per cent of line voltage for starting; the 65 per cent tap is the one ordinarily used for average conditions.

Fort Worden, Wash. E. I. PEASE.

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Replying to F. H. in a recent issue, while the calculations as a whole are rather complicated, they are all based upon Ohm's law.

It may be said first that good, sound judgment must be used in every case, as the drives for different machines vary greatly and these variations must at all times be considered, especially in the case of large drives and on important machines with special characteristics.

For instance, a drive on a machine requiring constant torque and starting under full-load condition with probably an allowable maximum motor starting current of say 180 per cent of full-load current, cannot be considered in the same manner as a large fan which starts under no load, the load increasing with the speed of the motor. If F. H. will notice closely the catalogs of the various controller manufacturers, he will see that each starter or controller is adapted only for a certain kind of service and the apparatus is intended only for that service specified. Disregard of these precautions is usually accompanied by dissatisfaction with the apparatus and the manufacturer is blamed unjustly. In the past these complaints have been legion and the larger industrial plants today usually have a works engineer or industrial engineer who properly selects and applies apparatus of this nature.

Motor control and starting apparatus is usually divided into several classifications. A simple starter is a starter and nothing more. If used otherwise a burnout is usually the result. A controller is designed for the control of motors or other electrical devices requiring similar control. The types of equipment and methods of control are many. A good work on this particular subject is Fox's "Principles of Electric Motors and Control" published by McGraw-Hill Book Company, New York, N. Y. This book covers everything the average maintenance man can use on this subject and the principles are very clearly explained.

Assume that we wish to calculate the starting resistor for a 35-hp. shunt motor operating on 230 volts, 130 amp. full-load current. Assume that the resistance of the armature brushes, leads, etc., is 0.02 ohm. Since the maximum starting current is to be limited to 180 per cent of full-load current, 130 amp. $\times 180 = 234$ amp. As the line voltage is 230 volts, then by Ohm's law 230 volts $\div 234$ amp. $= 0.983$ ohm. Since it will require 0.983 ohm to hold the maximum current inrush to 180 per cent of full-load value, it is evident that the resistance of the armature, leads, brushes, etc., is included in this total, as they are in series with the motor armature. The resistance of the armature was taken as 0.02 ohm. Then $0.983 - 0.02 = 0.963$ ohm to be included in the starting resistor. This resistance will hold the maximum current rush down to about 234 amp. This inrush of current is only momentary, for the armature starts to revolve the instant the rheostat is moved to the starting position and as the speed of the motor increases the cutting of the flux of the shunt field by the armature conductors generates a back or counter-emf. in the motor, which opposes the line voltage and limits the current flowing from the line. The starting resistance permits only a safe current to flow when the armature is stationary, in order to protect the motor windings. When the rheostat is moved to the second position, another peak or inrush takes place and the armature further accelerates, allowing the line current to drop again to a safe value. This operation is repeated until the motor has accelerated to its full-load speed, at which time the counter-emf. holds the line current to its full-load value or at a value corresponding to the load placed upon the motor.

I have found the following table, which gives the per cent of the total resistance in the starter, for each step of a five-step starter, to be very useful:

1st step = 30 per cent of total ohms.
2nd step = 24 per cent of total ohms.
3rd step = 19 per cent of total ohms.
4th step = 15 per cent of total ohms.
5th step = 12 per cent of total ohms.

Applying this table to the problem above, we would have:

1st step $= 0.963 \times .30 = 0.2889$ ohm.
2nd step $= 0.963 \times .24 = 0.2311$ ohm.
3rd step $= 0.963 \times .19 = 0.1830$ ohm.
5th step $= 0.963 \times .15 = 0.1445$ ohm.
5th step $= 0.963 \times .12 = 0.1155$ ohm.

It will be noticed that the resistance of the different steps varies, but the total always must remain the same for a given condition of load. Authorities differ on what constitutes the proper amount of the total ohms for each step, based upon their varied experiences. The results, however, generally are the same under average conditions.

The same starter can be used either on a shunt-wound or a compound-wound motor, under ordinary conditions, but where variable- or adjustable-speed motors are used and the larger part of the speed adjustments are made by a field rheostat changing the shunt field flux, somewhat different formulas must be used, taking into consideration these conditions.

For starting a series motor the ordinary type of starter is used, but as a series motor with a starter is rarely used except on hoists of the smaller type, and on cranes and other machines of like nature, a regulating resistor and controller are used. The formulas for the design of this type of resistor are more complicated.

Automatic controllers of the magnetic- and remote-control types are designed along similar lines for a given service, with the exception that less steps are required in the resistors for starters. Speed regulators, automatic control panels used for speed regulation of various machines, are designed with a certain number of steps, depending upon the amount of reduction required. The number of steps varies widely; on some machines three to five steps are considered sufficient. On others the complexity of the work requires even 10 or 15 steps, and on some of the large printing press controllers 18 or 20 steps are used.

In order to design a satisfactory controller, speed regulator or starter most of the factors have to be known and the available motor data must be furnished by the motor manufacturer. In addition, the designer has to consider other factors, such as the type of drive, the apparatus it is to be used on, the starting time the resistors are to be in actual service, starting torque, braking features and many others.

Chief Engineer, P. S. PENDER.
Metropolitan Engineering Co.,
Granite City, Ill.

* * * *

Answering F. H. in a late issue, one must remember that torque is expressed by the equation, $T = K \times \Phi \times i_a$, wherein T is torque, K is a factor which is constant for any particular machine, Φ is the main field flux and i_a is armature current.

If a motor is called upon to start a heavy load from rest, the starting torque may have to be as large, or even larger, than its normal full-load value. If the flux at starting has its normal value as provided by a shunt-wound field, then the starting current will, according to the equation, have to equal or perhaps be somewhat greater than the full-load value. But since the counter-emf. is zero when the armature is stationary, it is clear that at the moment of starting the armature current is limited only by the small armature resistance and incidental series field connections, if the motor is compounded "long shunt."

Evidently, the normal small running resistance of the armature must be increased at starting by inserting a rheostat in the armature circuit. As an example, a 10-hp., 220-volt, shunt-wound motor takes an armature current of approximately 40 amp. when carrying its rated load and has an armature resistance of 0.50 ohms. If full voltage were impressed directly upon the armature the initial current would be 440 amp., or more than ten times the normal full-load current. To limit the starting current to the full-load value, the resistance which must be put in series with the armature should be $(220 \div 40) - 0.5 = 5$ ohms. The resistance of the starting rheostat is usually calculated to allow the initial current to be somewhat greater than that corresponding to full-load torque. This resistance is gradually reduced in a number of steps as the motor comes up to speed.

Starting compensators for starting induction motors are nothing more than an auto-transformer from which various voltages can be obtained by means of taps taken off at various points of the winding. A large proportion of general-purpose motors have about 50 per cent of normal line volt-

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age impressed upon them when the compensator lever is in the starting position.

In the case of many large synchronous machines started by pole-face windings, the starting tap usually provides about 30 per cent of full line voltage.

CECIL H. GREEN.

Engineering Department,
General Electric Company,
Schenectady, N. Y.

* * * *

Why Does This Motor Run Slow?—We have two wound-rotor motors, each rated at 325 hp., 2,300 volts, 60 cycles, and 1,185 r.p.m. at full load. Both of these motors are running about 30 r.p.m below their rated speed. The frequency of the power supply is normal, for the generators are running at their correct speed of 3,600 r.p.m About nine years ago the ventilating fan blades were removed from the rotors of the motors and consequently during the summer the windings become quite hot. When the motors are running the pointer of the power factor meter swings continuously. The pumps that are driven by these motors have recently been overhauled, but there was no increase in the speed of the motor. Since the pumps are running at less than rated speed, the motors do not draw rated full-load current. Can some reader tell me what causes these motors to run at less than rated speed and how I should go about correcting the trouble?
Medicine Hat, Alta., Can. E. A. S.

In reply to E. A. S. in the May issue, I would say that his trouble lies in the rotors of the motors. My experience has been that where there is a drop in speed greater than that occasioned by the normal slip, the trouble has been in the rotor.

I am wondering if his controller goes to the full on position, shorting out the rotor, or whether it lacks one notch on the ratchet or star-wheel of going to the full on position, thus leaving one section of the grid resistance in the rotor circuit.

If the pumps are belt driven the flapping of the belt would tend to slow the motors down and cause heating.

Chief Electrician, EARL N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

* * * *

In the May issue, E. A. S. inquires why two slip ring motors run 30 r.p.m. below the full-load speed as given on the motor name plates. There are so many variable factors affecting the slip of a motor that manufacturers can not make any guarantee in this regard. The more resistance that is inserted in the secondary circuit of the motors, the greater will be the slip. If the motors have been in operation over nine years it is quite likely that the brushes now used on the slip rings are of a different quality of carbon and if their resistance is greater than that of the original brushes, then it would tend to cause a decrease in speed. E. A. S. also states that the motors run hotter than originally, due to the removal of ventilating fans. This would tend to reduce the secondary current with consequent decrease in speed. Anything that E. A. S. can do to reduce the resistance of the secondary circuit of these motors will tend to reduce the slip and bring the speed up as near synchronous speed as practicable.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

Answering the question by E. A. S. in the May issue, I would like to offer the following suggestions which I trust may be helpful to him.

First, it is possible that the bearings may have worn sufficiently to allow the rotors to rub on the bore of the stators when the motors are running under load. In some cases of worn bearings feeler gages do not tell the whole story. This is particularly noticeable in certain types of windings having parallel groups. In any doubtful case it is advisable to take the rotor out and examine both it and the stator for bright spots. It is also possible that some of the parallel connections in either the rotor or stator have become open-circuited. However, inasmuch as the motors do not draw full-load current, the trouble would appear to be in the rotor. I believe it would also be a good idea to check the power supply over carefully for frequency, and so on to make sure that there are no irregularities.

Stratford, Ont., Can. FRANK HARLE.

* * * *

In reply to E. A. S. in the May issue, the performance of these motors is, I should say, good rather than poor.

Almost any good electrical book gives very good explanations of the action of an induction motor, and from these it can be seen that an a. c. motor, unless it be a synchronous motor, cannot run up to synchronous speed, as it depends on slip for the rotor currents that create torque.

These motors must be six pole, and as the frequency is 60 cycles, the synchronous speed is 1,200. Therefore, a total slip of 45 r.p.m., or 3.7 per cent, from synchronous speed is about as good as could be expected. It is possible also that there are loose or poor connections in the rotor, in the brush leads, brush contact, or some other part of the rotor circuits, because an excessive slip can be caused by high-resistance rotors, as is especially noticeable in the older types of a. c. induction motors, which have soldered or brazed end rings in the rotors.

These explanations may not be the correct ones in this case. A closer inspection and examination would be necessary to enable one to say positively just what the exact trouble is.

As to the power factor variation, it may be inequalities in suction or lift of the pumps causing temporary variations in motor currents which, if much less than three-fourths load would be rising in power factor with higher currents, and lowering in power factor with lower currents, because of the natural characteristic of rapid rise in power factor from 15 to 20 per cent to 70 or 80 per cent from no-load to about three-fourths load.

Boston, Mass. EDWARD A. GIBBS.

* * * *

Replying to E. A. S. in the May issue, this trouble must be either exterior to the motors or be something which affects both motors in exactly the same manner. It might possibly be due to reduced voltage at the motor terminals, as the torque of a motor is proportional to the square of the voltage, for any given slip. This will affect the speed somewhat. Also, inasmuch as these motors have been in service for quite a period of years, it is possible that the increased heating caused by the removal of the fan blades, together with the natural deterioration of the insulation and corrosion of terminals due to soldering, may be introducing a higher resistance in the secondary.

Errors can also be made by depending on the frequency meter, as these meters do not always give correct readings. As an example, I know of three frequency meters on one system reading, 59½, 60 and 60½, respectively. Erroneous results are sometimes obtained when checking speed with the tachometer. Only a short time ago I had an expensive tachometer read 732 r.p.m. on a checked speed of 727 r.p.m.

I would assume from your statement that the power factor meter may register in accordance with the pump cycle or pump characteristics. This point can be determined by noting the relationship which exists between the reading of the meter or the movement of the pointer and the pump cycle.

It is an easy matter to check insulation resistance to ground, and from phase to phase. As a matter of fact, it is not difficult to run a complete test on an induction motor, but I would suggest that the above-mentioned points be checked first.

West Allis, Wis. EDWARD JAMES.

* * * *

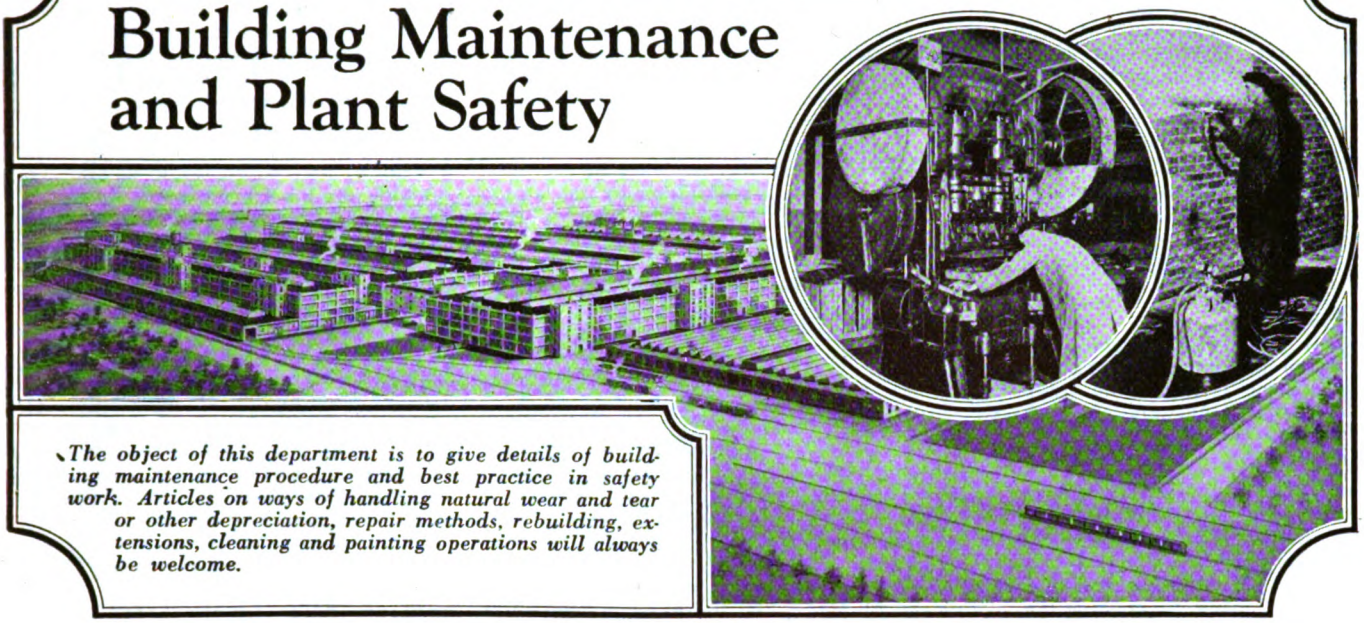
Replying to E. A. S. in the May issue, assuming that the frequency is definitely known to be 60 cycles I would suggest that the rotor be gone over very carefully and all connections at the ends of the rotor coils examined closely, as very often a connection may appear to be good and still have a good deal of the solder melted out causing a high-resistance joint. Several connections with poor joints will cause a motor to act very queerly. After the motor is up to speed, short-circuit the slip rings at the motor by putting a piece of heavy copper wire across the brush holder. After making sure that the rings are well shorted, take another reading of the r.p.m. and note if there is any increase in the speed. If there is an increase look over all connections at the controller and the grid resistance, as this is an indication that the controller is not short-circuiting the rotor properly on the last notch. If there is no increase in speed the trouble no doubt lies in the rotor.

I note that the speed of the motors at full load is 1,185 r.p.m. The synchronous speed would, of course, be 1,200 r.p.m. It appears, therefore, that these motors have very little slip for wound-rotor motors. Ordinarily a wound rotor motor has a slip considerably greater than a squirrel-cage motor. It seems to me that about 1,150 or 1,160 r.p.m. would be a good, full-load speed for a six-pole, 60-cycle, wound-rotor motor. Sometimes the nameplate data becomes disfigured and it is quite difficult to get the numbers correctly.

Electrical Engineer, WM. B. CONE.
Shevlin-Hixon Co.,
Bend, Ore.

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Building Maintenance and Plant Safety

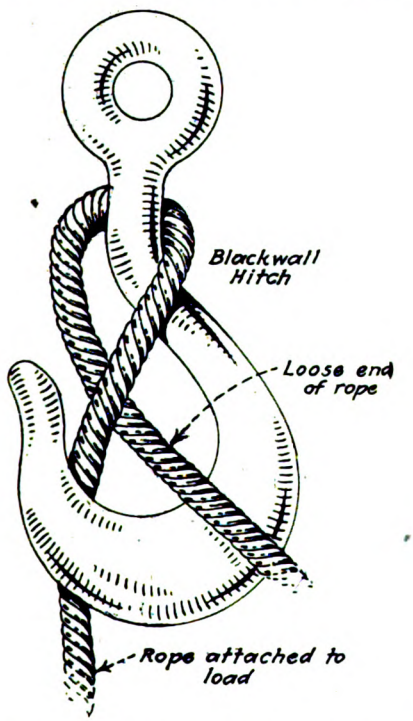


The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

How to Tie the "Cat's Paw" Hitch for Lifting Heavy Loads

FOR hoisting ordinary loads attached to a single rope, where a loop or sling is not used, the novice frequently has some difficulty in attaching the rope to the hook. For ordinary light loads, particularly where no danger is involved, the Blackwall hitch, shown in the smaller of the accompanying sketches, is frequently used. However, when heavier pieces are to be handled, the hitch known as the "Cat's Paw" is quickly made and easy to use, especially where short pulls must be made, and the blocks drawn up several times, as in the case of rope attached to a pole line or to a wire which is being pulled into a conduit when the overhead room is small. The method of making this hitch is clearly shown at (A) in the accompanying sketch. How it is applied to the hook is shown in (B). It is best to hold the loose end of the rope on each style of hitch at least until the load has pulled the hitch tight, to avoid the danger of it slipping.

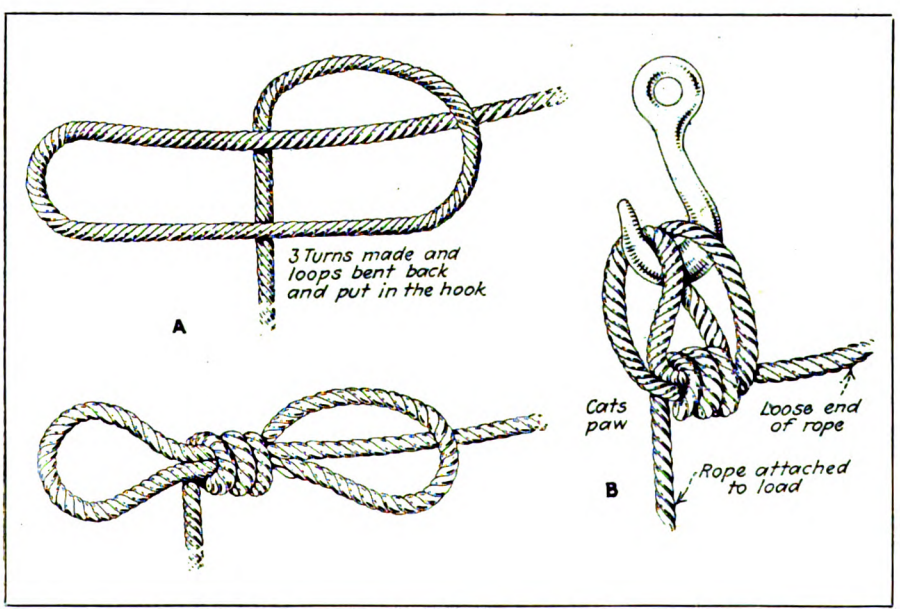
Oakland, Calif. S. H. SAMUELS.



This shows the method of tying the Blackwall hitch which is used for handling medium light loads. For heavier loads the Cat's Paw hitch, shown in an accompanying illustration, is generally more satisfactory.

These sketches show how the Cat's Paw hitch is made.

This is most commonly used where it is necessary to make several hitches in a rope to draw it up tight, as when pulling wire in a conduit and for other similar purposes. For heavy pulls it is more satisfactory than the Blackwall hitch, shown in the accompanying illustration.



Lineshaft Driven Fan Helps Keep the Shop Cool

IN A machine shop and foundry that occupies a group of old buildings, the fan, shown in the illustration on the next page, is used successfully. Part of the machine shop is in a room which is pocketed, so far as air circulation is concerned, and has an unusually low ceiling. Two of these fans are installed there and the men report that they would rather work in this section in the warm weather than in any other.

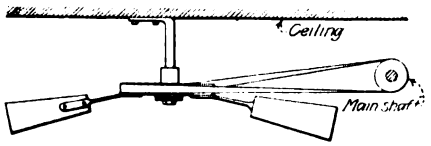
The fans are simple affairs that cost about $5 each to put up and practically nothing to run. They are belted from a lineshaft that runs 120 r.p.m.; the fans run about 50 r.p.m., which is ample to keep up a circulation of air, but not enough to cause drafts nor stir up dust.

To make these fans a single piece of old bar stock was bent at right angles and screwed to the ceiling. It is threaded for a nut at the lower end and above that is an old thrust bear-

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ing. A pulley salvaged from the foundry scrap heap comes next and to it are attached two arms of ½-in. steel, which are flattened out on the free ends so that the sheet-metal fan blades may be riveted on.

This outfit might be considered old-fashioned, alongside an electric fan,



This easily-constructed fan is driven directly from the lineshaft and keeps the air from stagnating in parts of the shop where the circulation is poor.

but it shows up well in first and operating costs and the results of an installation of this sort are very gratifying. If fans are installed in a shop with a low ceiling, some provision should be made to enclose the blades so as to prevent accidents.

Lubricating Kink Helps in Automatic Feeding of Material

PERHAPS two of the most important causes leading to diminished and inefficient production can be laid to frictional wear on machine parts, which requires frequent stoppage for replacement, and to difficulties experienced in obtaining smooth and continuous feed of material over frictional bearing surfaces. The obvious solution of these difficulties is lubrication.

For trimming the "burr" or "flash" from the bearing surface of large, hot-forged, track bolt nuts, the Buffalo Bolt Co., uses a series of electrically driven, semi-automatic, nut-burring machines. The design and operating characteristics of these machines are as follows: At one side of the machine is a large wooden box in which the untrimmed nuts are stored preparatory to trimming. A girl operator places the nuts face-up in a gravity feed chute. The untrimmed nuts slide down the chute by their own weight and feed automatically, one by one, in front of a pusher-arm which shoves each nut under a vertical revolving cutter head.

As each nut is placed in position by this pusher-arm, the cutter head descends, trims the "flash" from the face of the nut, and then returns to its original position. The trimmed nuts are then pushed ahead by those in back; as the end of the guideway is reached, the nuts fall into a steel container placed on the floor.

In operating the feed action, however, two difficulties were at first encountered, particularly when feeding hexagon nuts. First, the friction action of the nuts scraping against the sides of the runway wore the metal so rapidly that frequent shutdowns and replacements were necessary. The second difficulty was due to the jamming of the hexagon nuts in the runway, because the width of the runway is made slightly larger than that of the nuts in order to permit free feed of the material. During the feeding operation two opposite sides of each nut are parallel with the sides of the runway which brings a corner of each hexagon nut against a corresponding corner of the one in front and in back of it. Due to the combination of these two features, the natural tendency of the nuts, when being forced along by the action of the pusher-arm, is to turn, so that each nut tends to climb-up on the nut in front. When this occurs the feed action jams and stops.

Both of these difficulties have been overcome by a simple and inexpensive method, which consists of sprinkling a small quantity of cheap lubricating oil on the pile of untrimmed nuts in the wooden container. The oil quickly spreads over the surface of each nut and covers it with a film of lubricant. This lubricant in turn is imparted to the main chute, the horizontal runway, and the cutter tools as feeding proceeds. Thus the nuts themselves keep the feedways automatically lubricated at all times, and thereby has been eliminated all jamming of the material and frictional wear of the machine parts.

Buffalo Bolt Co., ARTHUR L. GREENE.
N. Tonawanda, N. Y.

Points to Consider When Painting Exposed Sheet-Metal Work

SOME painters believe that tin roofs should not be painted until after the tin has rusted; also some tinners have a theory that galvanized work ought not to be painted at all. There is a bit of truth in each. Because tin and galvanized iron are extensively used for roofs, gutters and leaders it behooves every executive of the maintenance department to know how to take care of them; otherwise they will become more expensive than copper products. The first thing to consider is that the so-called "tin" or tinned iron and galvanized iron are ferrous products and will rust, once dampness gets through the protective coating.

There is a greasy film on the surface of new tin and a residue from the zinc-coating process on galvanized iron. The reason that men in the building trades wait before painting is to give the elements a chance to wash off these superfluities. It is better to have them off, but Nature does not draw the line close enough, with the result that rust often sets in at once and the removing process really starts an oxidation that never ceases. A coat of paint over rust does not stop the rusting.

Between the two extremes of painting too soon or waiting too long before painting, it is better to paint too soon; that is, paint when the material is applied. No harm can be done and certainly some rust spots will be avoided. The greasy surface can be painted over; or it can be cleaned first with a soda solution made by mixing ordinary washing soda with 20 times its volume of water and bringing the solution to the boiling point. On large surfaces it is possible to run the hot soda water on with a hose, but for the most part such jobs are relatively small and the hot water can be brought to the job in pails. The solution is applied to the surface with brushes or rags, and it dries quickly without causing rusting.

In so far as the writer has seen, there is no objection to painting new tin as soon as put down. The priming coat of paint will contain linseed oil as a vehicle, and whatever grease or oil remains on the tin from its manufacture, or has been applied to protect it, will be present in relatively small amounts and will be absorbed by and mixed with the oil of the paint. Roof or bridge paint, or machine paint, well brushed on, is a safeguard that should be applied at once and doubts as to its efficacy forgotten.

Galvanized fittings should be painted as a preventive of maintenance expense. It is safe to allow rain to wash off the surface coating, but the painting should be done not later than a month after erection.

The popular expression, "Do it now," applies more truly to the painting of outside construction than to inside work, especially if maintenance is kept in mind. If galvanized construction is good "as is," it is far better and will last twice as long when properly painted.

It has been the writer's experience with outside maintenance that good, priming-coat machine paint is suitable for outside metal parts. In our plant Sherwin-Williams machine paint is kept in stock to be used on the product. To purchase the few gallons of other paint necessary to coat leaders seemed ridiculous when there was a metal paint on hand which would stick to castings. This led to the experiment on roofs. When mixed with pure linseed oil, this paint has been applied to gutters, elbows and flashings. When thoroughly dry, a second coat of the brown or green outside building trim is then put over the black machine paint. So far as the writer knows, every application of this paint is in splendid shape. A neighboring plant uses an asphaltic paint that is mixed with gasoline for the priming coat on roofs and it, too, seems to be a good outside protector.

When possible, it is best to do roof and gutter painting in the summer season during periods of drouth. Paint has a weaker grip on metal than on wood, and surfaces that are nearly horizontal wash more than those that are vertical. To avoid this, painting should be done at a time when there are not likely to be heavy rains. Other outside painting can be coaxed along at almost any time of the year, but it is worth while to replace gutters in dry weather and paint them at once; it is better to do this than to have paint flowing out of the ground spout.

Elbows rust out faster than any other part of a pipe line and to prolong their life should be given two coats of paint before putting up. The elbow that takes away from a gutter can be painted and repainted without removing. It is worth the trouble, too, for it is usually the first part to rust out. This is due to the piling up of leaves and dirt which retain moisture.

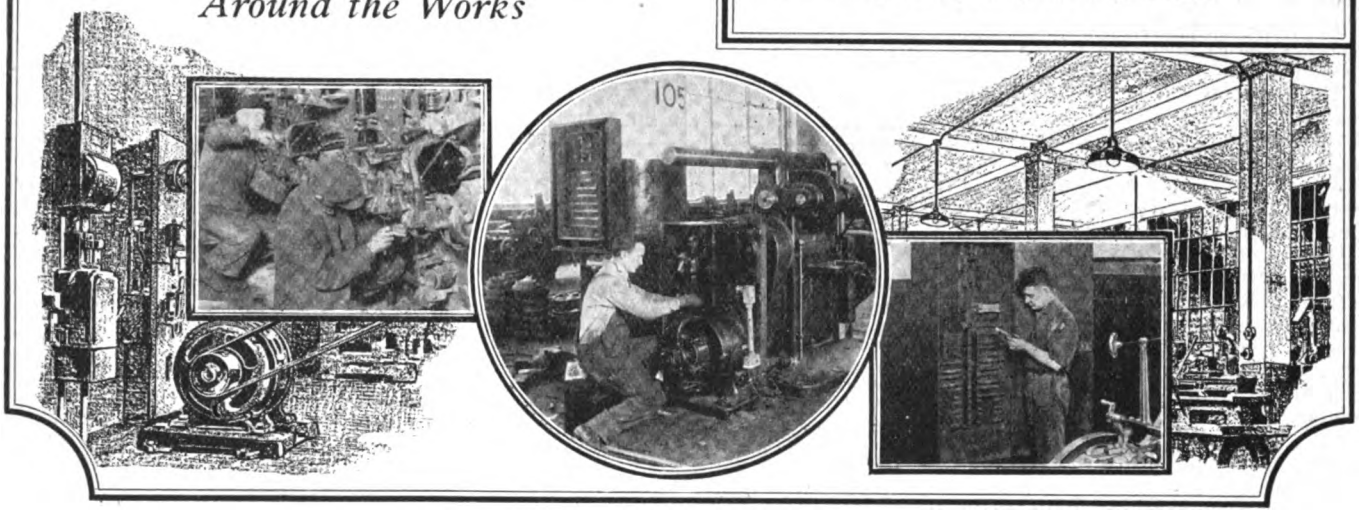
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Method of Using Test Lamp on Grounded Circuits

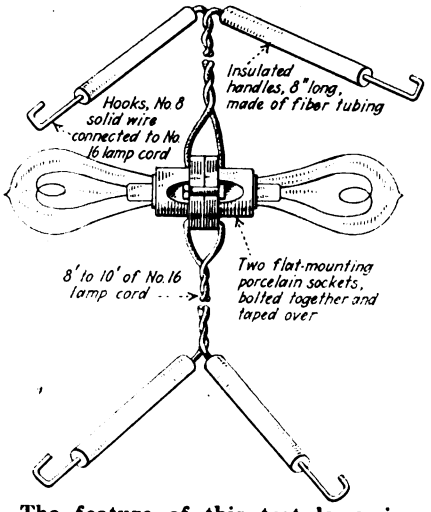
MANY electrical repairmen prefer a magneto and bell for testing motors for grounds and opens. This is a safe and convenient method, but hardly fills the need for testing motors, controllers and wiring where operating conditions involve service in the presence of moisture and chemicals. The magneto test is often deceiving under such conditions as in indicating a ground it does not discriminate between a solid and a high-resistance ground. The latter, however, is undesirable, and may come and go due to various conditions of moisture and temperature.

A very satisfactory testing device for general conditions is shown in the accompanying illustration. Two porcelain sockets are mounted back-to-back and bolted together. In each socket is placed a 50-watt, carbon or mill-type, 250-volt, lamp. This voltage of lamp will be satisfactory for use on 440-volt circuits. For 250-volt circuits, two 110-volt lamps may be used. The lamps are connected so that one lamp is in series with each test line. In other words, one lamp is in series with one of the test leads shown at the top of the illustration and with a corresponding bottom test lead. This prevents a flash or short-circuit to ground which might occur in case only one lamp were used in one test lead and no lamp in the other. In case only one lamp were used, a short-circuit might occur if the power supply used for testing became grounded, which is quite often the case, and one end of the test lead not having a lamp in series with it, were connected to the ungrounded side of the power supply and the other end of this same test lead connected to the grounded side of the device under test.

In order to prevent burning out a lamp due to a ground putting full line voltage on one lamp, a test should first be made from each line wire to the motor frame or the frame of the device under test, one side of each lamp, that is, either the top pair of test leads or the bottom pair of test leads in the illustration, is fastened to two of the line clips of the open motor switch. The other two test leads may then be used to test between the winding and frame or different parts of the windings, or to test fuses, compensators, and the like.

Quite often in case of grounds that are heavy enough to be serious, a small amount of smoke will be made during the test and the ground thereby located. The remainder of the winding will not be damaged. The resistance of the ground may be gaged by the brilliancy of the lamp, after some little experience.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.



The feature of this test lamp is that it affords safety to the user by having a lamp in series with each lead.

Either the top or bottom pair of test leads may be connected to the power supply. Then, when the other end of either test lead is connected to a ground and one side of the power supply is grounded, there will always be a lamp in series with the ground, thereby preventing a short-circuit that might injure the tester.

Trouble on Low-Voltage Trip Corrected by Time-Delay Relay

IN THE early days of electric power, interruptions to service were frequent and long. A slowing down and stopping of the motors warned the engineer that something was wrong. Through experience he learned that it was expedient to open the motor switch immediately when the service interruption occurred. If the motor switch were left closed when the service was restored the motor would be at a standstill and connected to full voltage, which caused many a burnout of the motor windings.

As the art of automatic protection developed, a low-voltage trip was installed on every motor switch. This consisted of an armature and a coil connected across the line voltage or across a potential transformer. The armature was mechanically connected to a device for opening the switch. When the line voltage dropped below a certain minimum, the coil would release the armature, causing the switch to open.

This protective device is at present installed on almost every motor switch. Only a few mechanical improvements have been made in the course of time. The device functions instantaneously and has served the purpose it was made for.

However, conditions have changed considerably since the time when this form of protection was devised. Modern power companies have only a few interruptions to service and most of these are extremely short. They are a mere flickering in the voltage; that is, a voltage dip, caused by some disturbance or switching on the power system. As the voltage during such a dip often drops lower than the holding voltage of the low-voltage coil, the low-voltage trip immediately opens the switch and shuts down the motor. This is unnecessary as the motor will stand for a short dip in voltage because the inertia

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of the rotating parts will keep the motor in motion for a short period. Consequently this kind of protection now causes more trouble in the plant than it prevents. In paper mills, ice plants, sugar refineries and the like, there are a large number of motors which are so essential to the manufacturing process, that even a short shutdown will cause a loss.

The result of this is that many plant engineers have preferred to eliminate the low-voltage coil or block it mechanically. This again endangers the motor windings in case a service interruption lasts so long that the motors lose too much speed.

On the other hand power consumers are getting used to such good power service that they hold the power companies responsible for losses caused by power interruption. This attitude gives considerable concern to power companies. Some of these apparently felt guilty for some other reason and tried to improve conditions by changing the customers' protection devices.

However, I believe that this is entirely the wrong attitude. It is true that some power systems could be improved and some of the voltage dips eliminated, although it is impossible to eliminate them entirely. Line disturbances are mostly due to lightning and accidental short-circuits. It is unreasonable to charge a power company for not being able to do the impossible. The status is rather confused now because some power companies have given in and many have not taken a definite stand.

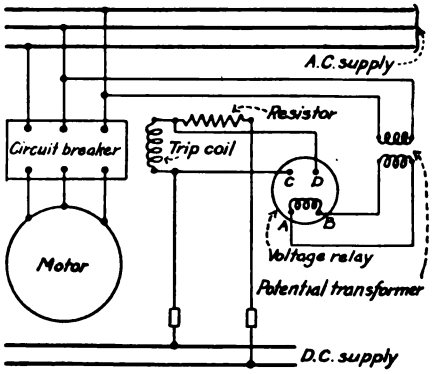
The solution lies in the use of a low-voltage trip attachment that does not function instantaneously but will hold on as long as the motor is running at such a speed that it can recover from the disturbance. A relay having a time delay will serve the purpose.

It is evident that the power consumer should pay for this improved protection. He did not object to paying for the instantaneous low-voltage trip. There is no reason why he should expect the power companies to pay for an improved protection.

To my knowledge there is at present no mechanical, time-delay low-voltage coil on the market. However, by using standard apparatus a time delay can be obtained, provided there is a convenient source of direct-current supply. This is possible with all synchronous motors, as the motor already depends upon direct-current for excitation, and this can be used for the tripping current. In the case of induction motors it is desirable to have a 12-volt battery. This will be objectionable for small installations, but in the case of large motors the additional battery cost is negligible.

The reason that a source of direct current is needed is so that there will be power to work the trip after the alternating-current supply has failed. If there were an alternating-current supply available that was absolutely independent of the supply for the motor, it could be used for operating the trip mechanism. To have two such power supplies would be very unusual, while having an independent direct-current supply would not be uncommon.

If a 110-volt direct-current supply is available, the original alternating-current, low-voltage coil can be used in most cases. A resistance is connected in series with this coil, which should be of such value that when coil plus resistance are connected across the 110-volt direct-current supply, the current flow through the coil will be equal to the original alternating current that flowed through the coil. A standard voltage relay having an inverse time element, such as a Westinghouse type CV relay, is connected across the line voltage or the secondary of the potential transformer in the same way as the low-voltage coil was connected previously. This connection is shown in the accompanying diagram.



A voltage relay having a time element prevents shutting down the motor in case of momentary dips.

The operating coil *AB* is connected across one phase of the alternating-current supply, as shown. In case the voltage dips below 60 per cent of normal the relay begins to operate. After a time interval, which may be adjusted to suit the individual requirements, the contacts *CD* are closed, thus shorting the trip coil on the circuit breaker and causing the oil switch to open.

The relay will start closing its contacts when the voltage falls under 60 per cent of the normal voltage. It is desirable to set the time element of the relay so as to close the contacts in one second when the voltage drops instantaneously to zero. These contacts will short-circuit the low-voltage coil and thus open the motor switch. This gives a time delay in the action of the trip, which will keep the motor on the line during momentary voltage dips.

The cost of this change consists of the cost of a resistance tube, of a standard relay, and of some wiring. This is usually liberally paid for if the arrangement eliminates one or two shutdowns.

Several plants have been equipped with this arrangement, and I have found that the results obtained are very favorable in each case. One plant had nine shutdowns during 1923. In January, 1924, the above arrangement was installed, which resulted in totally eliminating shutdowns during that year.

It is self-evident that this or any similar arrangement can only eliminate trouble due to voltage dips of short duration. It is impossible and inadvisable to keep a motor on the line if the power supply fails for longer intervals.

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Westinghouse Electric & Mfg. Co.,
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Saving Due to Care in Turning Out Mill Lights When Not Needed

THE importance of turning out electric lights when they are not needed, is frequently not realized. However, this is an example of a very large, needless expense which runs up the lighting costs markedly in a plant of any size.

In one of the large works investigated by the writer it was estimated that 35 per cent of the lamps of 400 watts and larger were left burning when not needed. The lighting load amounted to about 400 kw. After a little educational work by authority of the management only about 5 per cent of the lamps were left burning in the day time.

The saving was estimated at 1,440 kw.-hr. per day, which at the low cost of 1¼ cents per kw.-hr., amounts to $18 per day. In the course of a 300-day year this means a saving of $5,400.

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Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

How Variations in Voltage and Frequency Affect Induction Motors

IN THE second edition, April, 1925, of The Electric Power Club's *Motor and Generator Handbook*, the following comments are made regarding the performance of induction motors when operated at voltages and frequencies other than those for which the motors were designed:

Induction motors are at times operated on circuits of different voltage or frequency from that for which the motors are rated. Under such conditions, the performance of the motor will vary from the standard rating. The following is a brief statement of some operating results caused by small variations of voltage and frequency, and is indicative of the general character of changes produced by such variations in operating conditions.

Voltage variations of 10 per cent on power circuits are allowed in most commission rules. However, changing the voltage applied to an induction motor has the effect of changing its proper rating as far as power factor and efficiency are concerned, in proportion to the square of the applied voltage. Thus a 5-hp. motor, operated at 10 per cent above the rated voltage, would have characteristics proper for a 6-hp. motor (6.05 hp., to be exact); and at 10 per cent below the rated voltage, those of a 4-hp. motor (more exactly 4.05 hp.). It is, of course, obvious that if the rating of a motor were greatly increased in this way, the safe heating would frequently be exceeded.

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In a motor of normal characteristics, at full rated horsepower load, a 10 per cent increase of voltage above that given on the nameplate would usually result in a slight improvement in efficiency and a decided lowering in power factor. A 10 per cent decrease of voltage below that given on the nameplate would usually give a slight decrease of efficiency and an increase in power factor.

The starting and pull-out torques will be proportional to the square of the voltage applied. With a 10 per cent increase or decrease in voltage from that given on the nameplate, the heating at rated horsepower load will not exceed safe limits when operating in ambient temperatures of 40 deg. C. or less, although the usual guaranteed rise may be expected.

An increase of 10 per cent in voltage will result in a decrease of slip of about 17 per cent, while a reduction of 10 per cent will increase the slip about 21 per cent. Thus if the slip at rated voltage were 5 per cent, it would be increased to 6.05 per cent, if the voltage were reduced 10 per cent.

Higher than rated frequency usually improves the power factor, but decreases starting torque, and increases the speed, friction and windage. At lower than rated frequency, the speed is, of course, decreased; starting torque is increased; and power factor is slightly decreased. For certain kinds of motor load, such as in textile mills, close frequency regulation is essential.

If variations in both voltage and frequency occur simultaneously, the effects will be superimposed. Thus if the voltage be high and the frequency low, the starting torque will be very greatly increased, but the power factor will be decreased and the temperature rise increased with normal load.

The above facts apply particularly to general-purpose motors. They may not always be true in connection with special motors, built for a particular purpose, or as applied to very small motors.

An Example of What Plant Men Can Do to Help Speed Up Production

AN IMPORTANT part of the work of industrial men lies in providing many miscellaneous devices which facilitate plant operation and often production. This phase of the plant man's duties is well illustrated by the special car, shown in the accompanying illustration, which was constructed by the men in the *Electrical Department* of The Studebaker Corporation. Here it was necessary for a man to drive the automobile down an incline in taking it from one department to another and then to walk back up the incline to the starting point. To keep up with the output of cars demanded that the man walk about two and one-half to three miles a day up this 35 per cent incline at a fast pace. This was fatiguing and he would slow down on the work late in the day.

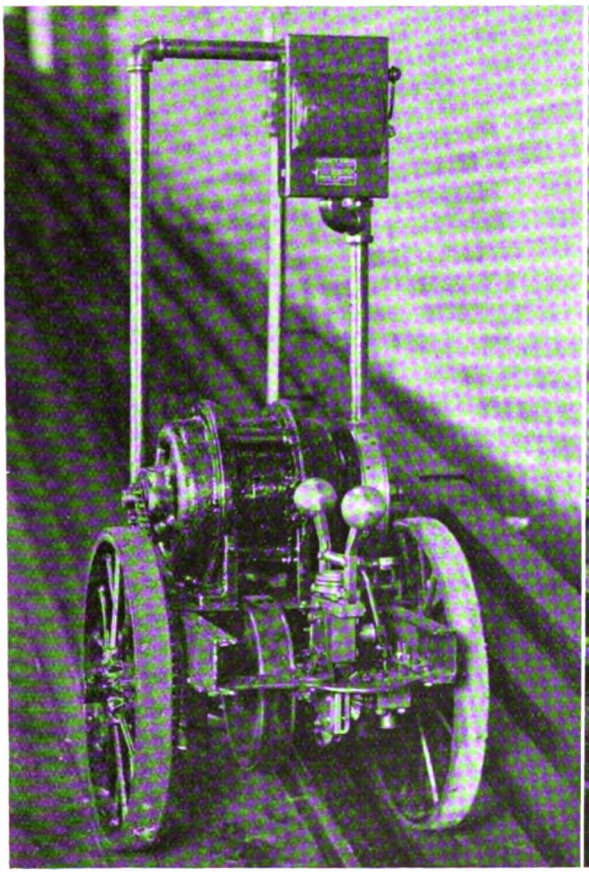
Finally, to relieve him of this uphill walk, the special car shown in the accompanying sketch was built. This is driven by an electric motor and controlled by the lever shown near the man's hand in the illustration at the right. The car is guided by an I-beam in the center of the track and is driven by the motor through chains and sprockets attached to the drive wheel. A fly-ball governor regulates the speed at which the empty car travels back down the incline by gravity. Current is transmitted to the motor through a brush contact on a trolley which is placed under an insulated beam close to the wall, as can be seen in the illustration at the left.

When the driver leaves the automobile at the foot of the incline, he steps onto the car, steadying himself by the handrails, and rides to the top of the incline. When he steps off the car, it automatically returns to the bottom of the incline by gravity. This car was constructed entirely from surplus, miscellaneous material.

The primary object of this equipment was to provide means which would not only make it easier for the man to get to the top of the incline, but also would speed up the operation, particularly toward the latter part of the day. This is only one example of the ingenuity which the typical plant man can apply in case of necessity.

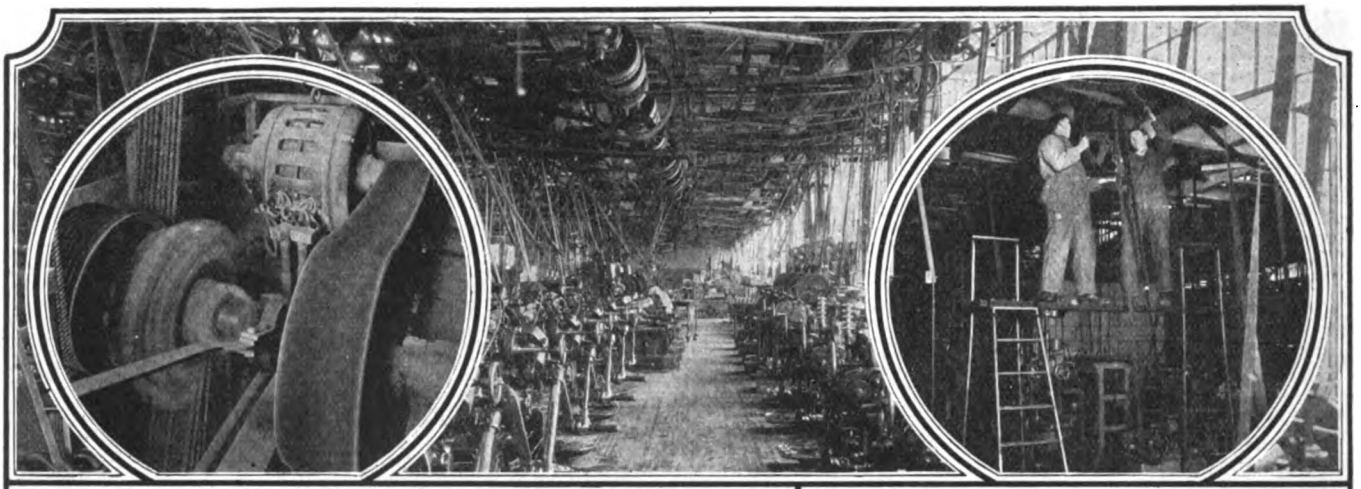
This car was built by the men in the Electrical Department of The Studebaker Corporation, to perform a special task.

In transferring automobiles from one department to another, a driver takes them down an incline. To get back to the top quickly enough to handle the next automobile necessitated almost running up a 35 to 40 per cent incline. This car, driven by an electric motor, carries the driver up hill faster than he could walk and returns to the bottom of the incline under the control of a fly-ball governor, so that it is ready for him when he comes down again.





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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Bearing Renewals in Centrifugal Pump Made Easy by Adding Bearing Pedestal

ONE instance of where maintenance kinks have made a saving in operating expenses was in the case of a heavy-duty centrifugal pump, of old-fashioned design, that was on 24-hr. duty where a shutdown caused a considerable loss in production. This pump was driven by a steam turbine, direct-connected, with a 600-r.p.m., 150-hp. motor idling on the opposite side as a standby drive.

The bearings on the pump were attached to the pump cover, and were of a solid type which entailed the withdrawal of the shaft through the bushing in order to renew them. To do this, first the turbine had to be disconnected, the motor disconnected and pulled back, the couplings on the pump shaft removed and the end plates on the pump casing taken off. Not until all this had been done could the shaft and impeller be drawn back far enough to slip the bearing bushing off. It took 4 hr. to pull the pump down, and at least as long to put it together again.

The maintenance engineer wrote to the manufacturer of the pump about installing a split bearing on a separate pedestal where it could be gotten at without all this trouble. There was no redress from this quarter, however; the pump was made in that way and there the matter must rest, as far as they were concerned. The maintenance engineer thought differently and made a visit to the scrap heap, the happy hunting ground of maintenance workers. An old pedestal was dug up that did not need much work on it to make it into a serviceable bearing base. The problem of finding a 3½-in. split bearing block was not so easy; so one was burned out of an old crank disk that had been discarded. This was machined up and slotted to carry a split bearing shell. A cap was machined out of the same old disk and fitted to the block. When all was ready to install the pump was shut down.

This was done nearly a year ago and the bearing has not given a moment of trouble. New bearing bushings can be slipped in in 10 min. Also, it is possible to take them up from time to time, which was never possible before.

This work probably cost in the neighborhood of $100 for labor, a few dollars' worth of scrap and the cost of a 3-hr. shutdown of the pump under the old conditions. Results of this sort can hardly fail to show the value of maintenance work even to the most conservative of managements, and they emphasize the point that maintenance is a safeguard against repairs, rather than something to be classed in the same category. MAURICE COCKSHOTT.

Los Angeles, Calif.

How to Line Up a Motor Pinion With the Gear It Drives

A UNIVERSALLY recognized, but so far unheeded, lack in the construction of electric motors is the absence of lining faces, such as machined surfaces or pads, that are parallel to the armature shaft in one or more places and which could be used to line the motor correctly with the shaft it is to drive.

When the motor is first placed, the average method used to align it is to provide a reasonably level platform for it to rest upon. The motor is made parallel with the shaft by some such means as, laying out a right-angled line on said platform, measuring with a stick at two sides of the motor casing, or by placing a straightedge against the pulley or gear on the driven shaft and trying to bring the smaller pulley or pinion (on the motor) to bear against this at opposite points on its rim. In some cases a motor has a sub-base with planed top and bottom and planed ways on which the machined feet of the motor slide. These may be readily aligned, but the ordinary sub-base has nothing more than cored slots to guide the motor.

A silent-chain drive will work fairly well, if the centers are not less than recommended by the makers, even though there is some inaccuracy in the motor setting. Of course, the life of the chain is thereby decreased but it will continue to carry its load as long as it will last. A belt drive will do as well as the chain as long as the imperfect setting merely puts a twist in the belt. However, if the shafts are not parallel, the belt immediately climbs the pulley. The result is that the belt either slips off repeatedly or delivers only fractional power because only part of its width is on the pulley. Also, in the latter case, part of the belt receives all the wear.

The gear drive, even though out of alignment, will continue to operate as long as the teeth are in mesh. Partly for this reason and partly because these close-up settings are hard to check, the gear drive generally receives less attention than the other types of drives. Except where the individaul motor drive is arranged for in the builder's design, it is safe to predict that fully half of the existing drives in use would be found to be inaccurately set, if a careful check were made. Even on many supposedly correct drives, the motor has planed feet resting on flat surfaces which permit sufficient shifting to reduce by half the life of the gears.

Replacements of gear drives by chain generally originate in the desire for more quiet operation; however, the noise of properly cut and meshed gears on correctly aligned shafts should not be so great as to warrant the expense of changing for this reason alone. With noisy gears, generally much of the noise is due to the fact that the teeth are not correctly meshed and wear much more rapidly than do gears where the teeth carry equal loads and are perfectly aligned.

The writer knows of one installation where an 18-to-54 tooth, 3-in. pitch

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drive was replaced every month for a year before the maintenance man told the owner that the gears wore from lack of alignment. The man who had put in the motor leveled up the timbers on which it was mounted and lined the shafts with a stick, which was all he had to work by. This was only an approximate setting to begin with and the timbers sagged in time, making things worse. Probably it would not have cost 50 cents to have machined some surfaces on the motor when it was built which could have been used to check alignment. If these had been there and used it would have saved the buyer $50 a month because the original installer could have had something finished to work by. Also other mechanics could have used them when gears were changed. The lack of such faces caused them all to dodge the task of checking alignment.

It is possible, by taking more time to the work, to line up motors with considerable accuracy. The tools required are one or all of the following: micrometers or calipers large enough to make an over-all measurement when the gears are in place, a level, a straightedge, a measuring rod, and metal feelers. Good lighting is also necessary.

How the caliper measurement is taken is shown in *A* in the accompanying drawing. It is essential in this that the gears be turned straight on their outside diameter. Measuring the gears at each edge will disclose any inaccuracy in setting, although with a narrow gear face this test becomes less valuable. The use of a micrometer caliper makes this a most significant test because any marked difference in the readings shows that the gears are meshed deeper on one side than the other and that only when the tooth shapes become worn will there be a bearing clear across. The same test may be made even more advantageously when the gears can be removed from their shafts, because the shafts are usually longer than the face of the gear, which permits a greater spacing between the measurements. Also, a reading which is made directly on the shafts avoids the inclusion of possible error in the turning of the gear blanks. This misalignment may be corrected by shifting of either motor or machine part until the reading is the same at both points, which indicates that the gears are set to an even depth.

Another test for the same alignment is made as shown by *B*. Here, a straightedge is held against one face of the pinion and the rim of the gear checked with this at opposite points for parallelism. This test is performed to best advantage when the gear can be moved on its shaft, carefully, to bring it within paper-feeler distance of the straightedge or within the thickness of metal feelers. To be of real value, the face of the pinion and the rim of the gear must be cut true with the bore and the fit upon the shafts must be close enough to avoid rocking.

The level is an instrument of precision, even in the hands of the unskilled. A piece of paper the thickness of this page placed under one end of a 6-in. level will move the bubble about 1/32 in., which is easily noted on a graduated tube. In *C*, the shafts of an overhead planer drive have had the gear and pinion removed for the level test and for an over-all measurement, by calipers as at *A*. A short level is better than a long one, when used on stub shafts such as these. When the center line between the two shafts is roughly horizontal, one shaft that is not level will cause imperfect meshing, so that the teeth of the pinion will ride on one corner only and the teeth of the gear on the opposite corner.

Properly adjusted gears should have 0.002-in. clearance between teeth. A good test of this can be made with a 0.002-in. feeler or slip of newspaper, as shown at *D*. Such a test need be made at one side only and shows that the teeth are meshed to proper depth. An additional test for even setting across the face can be made with metal feelers or with a piece of wire filed in the lathe to a slight taper. This piece is inserted in the space marked *s* in *D*. If the taper piece goes in the same depth on each side, the shafts may be assumed to be parellel in that one plane. Feelers also show this.

By these methods, a motor can be lined with the driven shaft to a fair degree of commercial accuracy. The work is not open and direct, but requires care and patience because the measuring points are close together and some of the measurements require a nicety of feeling not generally associated with millwrighting. This work would be much easier done if spots were faced off on top of the motor, on each side, and a cut taken across the ends of the feet, which would provide known working points in two planes and at a good distance apart.

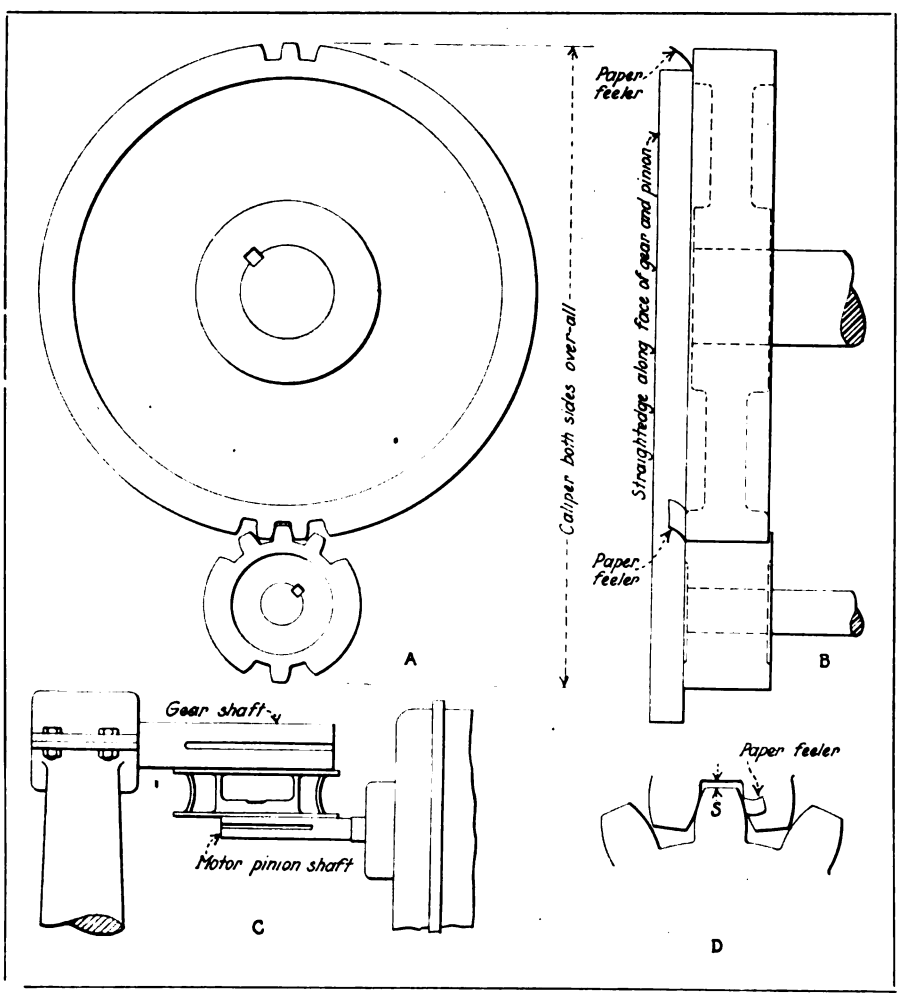
To secure the benefit of widely spaced measuring points, a measuring rod or tram can sometimes be employed to read between the driven shaft and the centers of the armature shaft. All motors are not open at the rear end, but some have a removable plate that will expose the center in that end. If properly done, this is a good check.

The large and unnecessary cost of pinion renewal is a big drag on upkeep funds. Many worn pinions are scrapped for so-called "noiseless" ones which also wear because they are not properly aligned.

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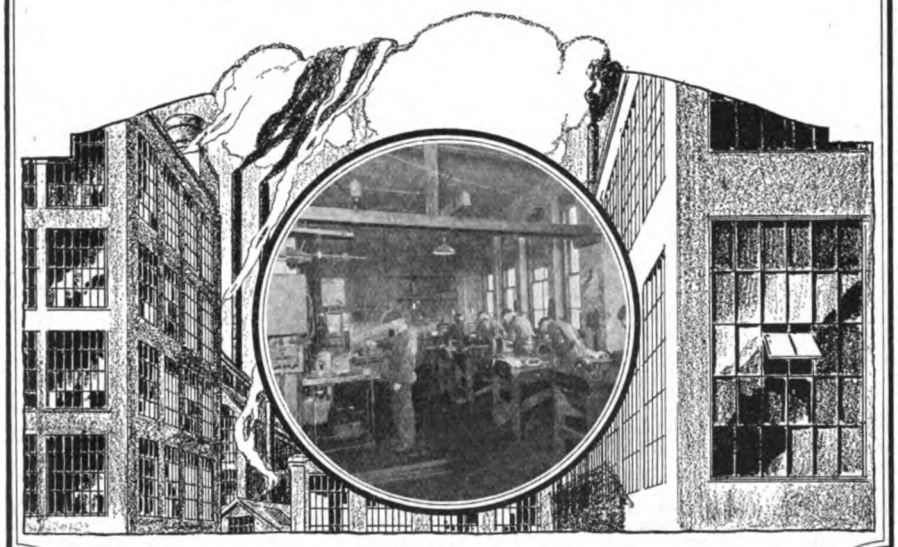
Four methods which may be used to check alignment of a gear and its driving pinion.

When gears and pinions are not aligned correctly they do not mesh properly, are noisy and wear rapidly. Where the face of the gear is wide enough, calipering the outside diameters, as at *A*, will show the correctness of the setting. If the sides of the gear and pinion are true and they can be slipped along the shaft a straightedge, *B*, can be used. Perhaps a still better method is to remove the gears and pinions and check the shafts with a level as at *C* and also with calipers as was done in *A*. Revolve the shafts 90 and 180 deg. and test with the level to see that they are not bent. Paper feelers, *D*, used as shown, and a metal feeler at *s*, are additional checks which can be relied on only when the teeth are true and not worn by previous misalignment.



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In the Repair Shop



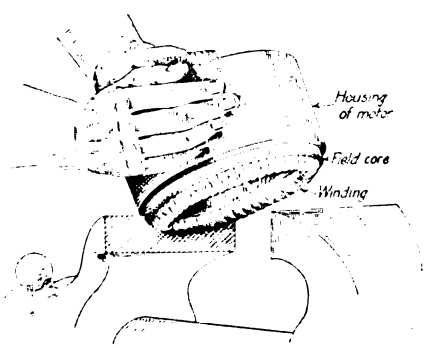
This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

How to Remove Field Cores from Fractional Horsepower Motors

THE article by G. H. Ennis on page 302 of the June issue on removing tight fan motor field cores, reminds me of the method I devised and use for this work. A standard vise is the only tool required to remove any style of core.

The field core of the motor usually projects out of the housing a distance of ⅛ in. or more so as to form a seat or joint for the removable end bell. The jaws of a vise are opened wide enough to permit the field core to pass, but not far enough to let the housing of the motor go through. Naturally all screws and bolts holding the core to the housing must be removed.

By bumping one edge of the housing on the jaw of the vice, as shown in the accompanying illustration, and turning the motor around slightly every few bumps, the field core will slide out of the shell. Only one side is bumped on the jaw at a time while the other is held on the other jaw to act as a hinge.



By resting one edge of the motor housing on one jaw of the vise and bumping the other edge of the housing against the other jaw, even a very tight field core may be easily forced out.

The jaws of the vise should be square, or sharp to prevent battering of the edge of the housing. I have never seen a core fail to come out by using this method, no matter how tightly it fitted in the housing. The edge of the housing may be battered slightly, but that is better than damaging the windings or the core as is usual when hammering on a punch placed through the vent holes against the end of the core. The burrs on the housing can be removed with a file.

This method seldom requires over five minutes to remove the tightest cores, which I have seen require nearly an hour by other methods. Further, it can be used on any kind of a fan or other fractional horsepower motor. Large cores can be removed in the same manner by bumping them on angle-iron bars fastened to supports.

Chicago, Ill. CARL G. HOWARD.

How to Dip and Bake Armatures to Secure Long Life

IT IS becoming generally agreed that dipping and baking armatures results in considerably longer life between rewinds and thus is decidedly worth while. The following procedure for cleaning, repairing, preheating, dipping, draining and baking has been subjected to recent investigation and is now being used with considerable success. For armatures being overhauled, the following procedure is recommended.

Cleaning—When the armature is very dirty remove the dirt and grease with a scraper. Then clean with benzine or gasoline by spraying, brushing or dipping.

Repairing—Remove the bands and insulation on the end windings and make necessary repairs. Make sure that the core bands are tight and that the coils are tight in the slots. If either are loose, reband, placing a filler in the slot when required to get pressure on the top of the coil; make sure that the bands are down on the iron.

When wedges are used, inspect them for tightness; if it is thought they will not tighten when dipped, it is best to rewedge, using fillers under the wedges to make the coils tight. Place temporary bands on the armature if there is a tendency for the coils to spring out of position while being dipped. Place the bands in such a manner that the armature will drain readily after dipping.

Some operators may wish to dip and bake their armatures without removing the bands or hoods. In such cases, care must be taken to see that the armatures drain and bake out satisfactorily. This is necessary to eliminate all trouble due to wet varnish inside of the armature.

Pre-Heating or Drying—Heat the armature in an oven having a free circulation of air, at a temperature of 98 to 105 deg. C. (208 to 221 deg. F) for the length of time indicated below: Armatures below 12 in. diam.—12 hr. Armatures 12 to 30 in. diam.—18 hr. Armatures over 30 in. diam.—24 hr.

Dipping—While the armature is still hot (approximately 50 deg. C.) dip in a good grade of baking insulating varnish. If it is dipped while too hot too much varnish will drain out. A black baking insulating varnish with a specific gravity of 0.840 is recommended, but other approved varnishes may be used, the specific gravity depending on the varnish and the thickness of the varnish coat desired. Should the varnish be too heavy, thin with benzine.

Dip the armature in a vertical position, commutator end up, and to such a depth that the varnish will come only to the commutator neck. Allow the armature to remain in the varnish for approximately 5 min. If a vapor arises from the varnish in large quantities this indicates that the armatures are too warm when being dipped.

Place all double-commutator armatures in a horizontal position so they can be rotated in the varnish to twice the slot depth. In case they cannot be rotated as described, pour varnish over the armature until the windings are filled.

After an armature has been dipped, wash off the varnish on all the finished metal parts with a cloth saturated with benzine.

It is important that the commutator be not immersed. If this should happen the varnish may work inside of it and be trapped, and experience has shown that it is almost impossible to drain it out or bake it satisfactorily.

Some operators roll armatures in a tank or trough instead of completely dipping them, and apparently get good results. When this is done armatures should be rotated slowly several times to insure that all coils are thoroughly soaked with varnish.

Draining—Drain at room temperature until dripping ceases, which will

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require 15 to 20 min. Place the armature in such a position that there will be no pocketing of the varnish in the winding or the iron. When the armature is such as to require draining in other than a vertical position, turning will be necessary to avoid the gathering of varnish at one point. The amount of turning will depend upon the construction of the armature.

Baking—Bake the armature in an oven at a temperature of 105 to 115 deg. C, maximum at armature, until dry. This can best be determined by taking the insulation resistance with a megger. A constant reading for three separate tests indicates a dry armature. For most cases the length of time as given below will be sufficient to set the varnish thoroughly.

Armature below 12 in. diam.—48 hr.
Armature 12 to 30 in. diam.—60 hr.
Armature over 30 in. diam.—72 hr.

Bake the armature in such a position that there will be no pockets of the varnish when it is dry. In baking the armature in a vertical position, care must be taken in placing it in the oven so as to get a free passage of air through the air ducts and around the outside of the armature. Ventilation which provides a change of the air is necessary to secure the best results in baking.

When an armature is so constructed that the varnish tends to pocket when the armature is baked vertically, or in the case of dipping and baking with end bands and hoods in place, bake in a horizontal position. Such armatures are the old style ventilated ones with radial air ducts. Armatures baked in this position should be turned during the baking so as to avoid any gathering of the varnish at one side of the armature, which would tend to unbalance it mechanically. It is recommended that the hoods and bands of an occasional armature be removed after being dipped and baked and the winding inspected to determine whether or not the desired results are being obtained.

For armatures that have just been rewound, the following procedure should be observed:

Banding—After rewinding and soldering, place the armature in an oven for 8 to 10 hr. for heating before banding. If coils are high and it is thought that it will be difficult to get them down, and at the same time have tight bands, run on temporary bands. Use material enough under the bands so that the wire will not damage the winding. Place the bands so that there will be no tendency for the varnish to pocket during the dipping and baking.

If no temporary bands are needed, run the permanent bands on the core, but if the armature is baked in a vertical position, the hood and only the end bands that are up during the baking can be applied.

The armature is now ready for the dipping and baking and the procedure given above, beginning at *Dipping* should be followed.

In dipping and baking armatures the following precautions and hints will be found helpful:

If steam is used for heating, do not permit the steam to escape into the oven, thereby giving the apparatus a vapor bath. Do not permit the temperature to exceed 115 deg. C. at the armature.

Do not rush the baking period. A wet armature is worse than one that has not been treated.

Provide for the ventilation of the oven. Arrange for a complete change of air, eight or ten times an hour. Holes near the top and the bottom of the oven will usually provide a good natural ventilation.

Make sure that the temperature of the oven is uniform and maintained at the correct value.

Turn armatures frequently, if they are baked in a horizontal position, to prevent unbalancing.

Use an approved grade of black baking varnish.

Dip the armatures, keeping the commutator end up.

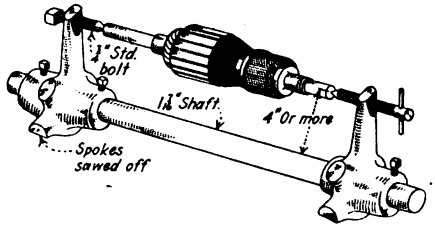
At one time it was recommended that armatures be baked at a temperature of 125 deg. C. from 24 to 48 hr. depending upon the size of the armature. This has been changed as it was found advisable to reduce the temperature from 125 deg. C. to 105-115 deg. C. maximum at armature, and to increase the time of 24 to 48 hr. to 48 to 72 hr. The reduced temperature at an increased baking time gives the best results, as the danger of taking the life out of the insulation is removed and the varnish bakes more evenly as the varnish on the surface of the armature does not set so rapidly. Experience and considerable experimental work confirms my opinion that the lower temperature should be used in order to obtain the most satisfactory results. The only advantage of the higher temperature is that the time of baking may be shortened thereby giving an increased production, and it is being used by some operators with apparently satisfactory results.

Wilkinsburg, Pa. A. C. ROE.

How to Make a Workstand for Small Armatures

OLD pulleys that had been through a fire were used in constructing this stand for small armatures. As can be seen from the accompanying diagram all except one of the spokes on each pulley were sawed off.

The pulleys are mounted on a short piece of shafting and fastened tightly to it by means of set screws. The shaft may be clamped in a vise to hold it in position, or it may be laid on a bench if so firm a mounting is not needed.



This stand is made from two old pulleys, a short piece of shafting, three set screws and two pointed stud bolts.

Through the upper ends of the two spokes a hole is drilled and tapped to receive the pointed bolts which act as centers to hold the armature.

This stand is heavy in construction and very useful for straightening small armature shafts. In this case the stand must be held in a vise and blocks laid on the vise as a fulcrum for a lever in applying force to straighten the shaft. After each attempt the armature may be tested on the centers to see if it is true.

Durant, Okla. J. P. KINCAID.

Method of Straightening and Cleaning Busbars

IN REVAMPING a switchboard installation for different conditions it was found that the rebuilding of the copper busbar structure could be most easily and safely accomplished by taking down the old buses, straightening out the bends and rebending them to fit the new conditions. No doubt, some of the bent busbars could have been used again by sawing off and splicing them to fit the new conditions, but after making a layout of the switchboard and trying to fit the old busbars to it, it was found that there would be too much loss of time for the slight benefit gained.

Accordingly, all of the busbars were sent to a coppersmith for straightening. The price for straightening these bars was 25 cents per bend, which we thought was quite reasonable. It was necessary for him to anneal the bend, then roll it as straight as possible, after which a careful peening was necessary to remove all traces of the old bend and to leave the busbars perfectly straight.

The original lacquer near the straightened bends on these busbars was discolored from the heat during the process of annealing. Several methods were tried to remove this discoloration. Paint removers were tried and found to be unsatisfactory. Neither alcohol nor ether was found satisfactory. Under this treatment, the old, discolored lacquer seemed to smear all over.

Sandpapering was then tried but found to be too tedious, as there were something like 275 bends that had to be cleaned. Sandblasting removed the lacquer and its discoloration all right, but the sandblast finish did not seem to appeal to the powers that be. Boiling in a caustic solution and dipping in acid gave very nearly the same finish to the copper busbars as did the sandblasting; so this process was also rejected.

We finally used a strip of fine sandpaper made endless and used on a modern sanding table, which is equally efficient for sandpapering wood or metal. This endless, sandpaper belt runs at a good speed and since a fine grade of sandpaper was used very little copper was removed with the lacquer by this process.

After cleaning all the bars in this manner, they were relacquered before being bent to fit the new layout.

Oakland, Cal. S. H. SAMUELS.

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Installing Oil Circuit Breakers

(*Continued from page 379*)

freedom of throwing switches into full contact.

(5) Check adjustments on the horns of horn gap switches.
(6) See that all joints are secure.
(7) Check all clearances.
(8) Inspect all contacts for alignment.
(9) Inspect primary fusible cutouts with regard to contacts. See that the insulating tubes are in good condition and clean and that the fuses are of the proper ampere capacity.
(10) Inspect all contacts for alignment.

It is recommended that sufficient spare parts be carried in stock to enable the operators of switching equipment to promptly replace any worn, broken or damaged parts.

Better Industrial Illumination

(*Continued from page 365*)

truly the vast difference between lighting conditions such as are commonly prevalent, and lighting conditions that measure up to modern standards. These conditions are illustrated in a general way in Figs. 1 and 3. Our eyes function under such a wide variety of conditions that under poor lighting conditions we are seldom conscious of the fact that more light would increase the efficiency of our vision and produce a psychological effect which would make us mentally and physically more alert.

A large majority of the factories in this country are underlighted. They are losing an opportunity to increase production and to enjoy other benefits of better lighting, with the minimum of increase in overhead, because they do not give the proper attention to the lighting systems of their plants. Perhaps the rehabilitation of their existing lighting system would only involve the addition of a few lighting units, or merely a thorough cleaning of the equipment to bring it within reach of modern standards.

While most of our knowledge of what good lighting is and what it will do has been acquired in a comparatively few years, we have only begun to utilize the possibilities of light. Every year sees new developments and new standards which help us to secure profitably a wider and better use of light. In this rapid progress, old lighting methods and lighting equipment fall in the same category as machinery which is superseded by improved machines that reduce labor costs and speed up production. In view of these facts, the factory executive will do well to concern himself with the lighting of his plant, even though the existing installation may be only a few years old. Usually there is no hesitation in putting in a machine which will pay for itself within a reasonable time by virtue of the improvements that are incorporated in it. By the same token, improved lighting should not be treated with indifference when it will definitely pay for itself in dollars and cents through increased production, reduced accident hazards, and improved working conditions.

Other phases of this subject will be discussed in two articles which will appear in later issues.

Practical Pointers on Winding

(*Continued from page 383*)

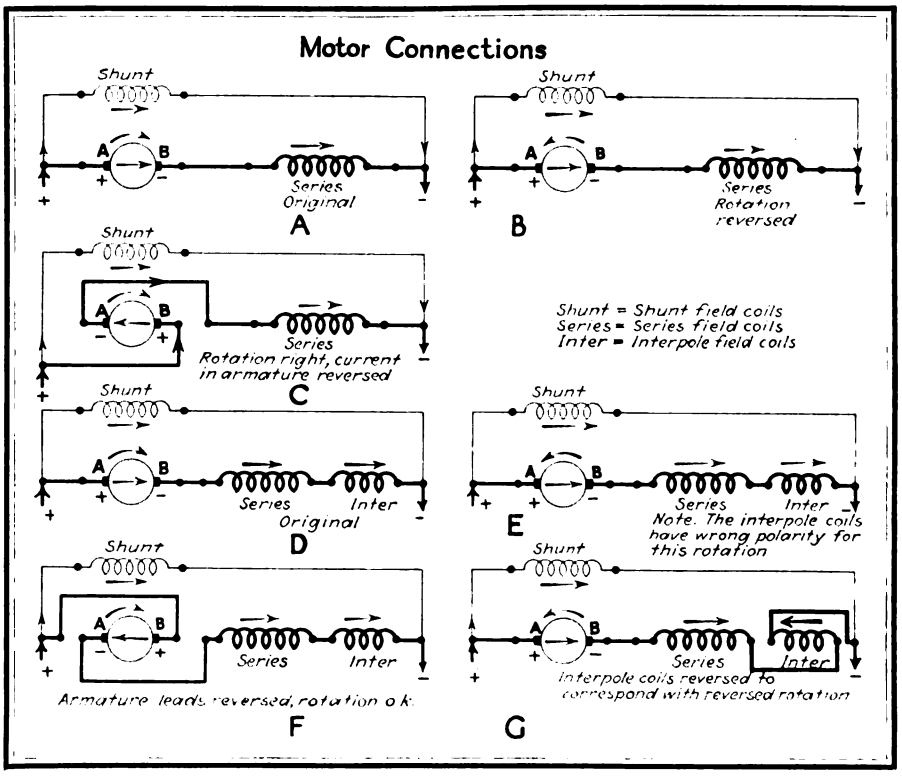
Fig. 6 *A* shows the standard setup for a compound-wound design. Note that with a motor we can show the current arrows for the series and shunt fields pointing in the same direction. In Fig. 6 *B* the armature winding has been changed, but the current arrows all point the same, the rotation having been reversed. Fig. 6 *C* shows the method of bringing the rotation back to standard by reversing the armature leads.

Figs. 6 *D* to 6 *G* show where it is possible to get into further trouble, when trying to correct a changed armature connection. Fig. 6 *D* shows a standard, compound-wound motor with interpoles. In Fig. 6 *E* the winding has been changed, resulting in a reversal of rotation. Now, if this rotation could be used, the polarity of the interpole coils would have to be reversed as shown in Fig. 6 *G*. This is explained by the following rule that applies to the polarity of interpoles in relation to the main coils and rotation:

In a generator an interpole will have the same polarity as the main coil ahead of it in the direction of rotation; it is immaterial which end of the machine we look at. In a motor the interpole ahead of any one main coil in the direction of rotation will have the same polarity as the main coil; therefore, if we change the direction of rotation, we must also change the polarity of the interpole coils. In Fig. 6 *F* the rotation has been brought back to standard by reversing the armature leads.

In the next article instructions will be given for taking data and also for marking the armature so as to insure its being rewound properly.

Fig. 6—These diagrams show correct and incorrect connections for compound-wound motors.



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Trade Literature

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Ball Bearing Speed Reducer—Circulars announce a new spur-gear speed transformer, which has ball bearings throughout and in addition has special housings attached to the frame of the reducer which enclose the couplings attached to the shafts on each end.—Albaugh-Dover Mfg. Co., 2100 Marshall Blvd., Chicago, Ill.

Storage Battery Industrial Trucks and Tractors—Catalog 140 describes and illustrates the construction of the various types of tructors (electric storage battery tractors and industrial trucks) of the lifting and elevating platform types as well as the general utility or stationary platform type, tractors, crane trucks and other special equipment. In addition, a large number of illustrations show applications in many plants in various industries.—The Elwell-Parker Electric Co., Cleveland, Ohio.

Lubricating Devices and Oil Filters—A group of bulletins describes the Bowser oil filters, lubricators and pipe fittings for oil lines, and shows special applications of this equipment to lubrication and oil purification in industrial and other plants.—S. F. Bowser & Co., Fort Wayne, Ind.

Non-Corrosive Metal—Bulletin 1 gives a brief technical description of Alcumite, which is an acid-resisting non-corrosive metal, which is produced in the form of castings, sheets, rods or bars. This folder gives the physical characteristics as well as corrosion tests.—The Alcumite Corp., Division of the Duriron Co., Inc., Dayton, Ohio.

Natural Cooling of Transformers—Bulletin 101 describes the H.J.M. cooling unit, which consists primarily of an automotive, core-type radiator mounted horizontally in a sheet metal stack. The transformer oil to be cooled is pumped through the radiator and cools by virtue of the natural draft of air set up in the stack. This device is applicable to transformer installations of 2,000 kva. and up.—Hanson, Jones and Morey, 219 West Seventh St., Los Angeles, Calif.

Magnetic Testing Apparatus—Catalog 10 describes apparatus for capacitance and inductance measurements and for magnetic testing; 48 pages are devoted to a description of the various types of apparatus and their use.—Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Laminated Bakelite—A folder describes briefly and illustrates a large number of the numerous products which may be made from Bakelite.—Bakelite Corporation, 247 Park Ave., New York City.

Quick Trip Graphic Meter—Bulletin 525 describes a special Esterline-Angus graphic meter in which, by means of a relay, any disturbance on the line changes the speed of the chart drive in 1/25 of a second from inches per hour to inches per second. When the disturbance ends, the relay resets the meter to the standard chart speed. This is to enable a careful study to be made of these disturbances.—The Esterline-Angus Co., Indianapolis, Ind.

Lubricators for Industrial Machinery—A bulletin with the above title, illustrates and describes a number of installations of McCord force-feed lubrication as applied in numerous industrial plants, such as on presses, forming machines, woodworking machines, glass bottle machines, toggle presses, rubber calenders and other equipment.—McCord Radiator & Mfg. Co., Lubricator Division, Detroit, Mich.

Panel and Benchboard Pipe Fittings—Bulletin 47703-C illustrates the different fittings and shows by sketches their applications, dimensions and specifications as well as the weight of each fitting listed in this 20-page booklet.—General Electric Co., Schenectady, N. Y.

Chain Blocks and Hoists—A booklet describes the self-lubricating, multiple-gear chain blocks which are built in sizes from ¼ to 20 tons' capacity, differential chain hoists, steel I-beam trolleys, the EverRedy electric hoist and double and single I-beam hand power traveling cranes.—Reading Chain & Block Corp., Reading, Pa.

Acid-Moisture Proof Propellor Fans—Bulletin 63 describes the Autovent propellor fans which are designed and constructed for use in places where surrounding hazards require the service of a fully-enclosed motor which will not be affected by acid fumes or moisture in the air.—Autovent Fan & Blower Co., 736-738 W. Monroe St., Chicago, Ill.

Direct Current Motors—Bulletin 141 describes the R. & M., constant-speed, d.c. motors from ¼ hp. at 870 r.p.m., to 20 hp. at 1,160 r.p.m inclusive. These motors are built in types S, C and I and are shunt and compound wound for standard voltages of 115, 230 and 32 volts.—The Robbins & Myers Co., Springfield, Ohio.

Automatic Arc Welding—Bulletin 48937.1, under the above title, gives a resume of the uses and value of arc welding, together with a description of the welding apparatus and generating equipment used. This bulletin is well illustrated by photographs of the equipment and applications.—General Electric Co., Schenectady, N. Y.

Pneumatic Tubes—Catalog 4 of the series, "Wherever Conveying Is Done," describes the equipment, arrangement and operation of pneumatic tubes, together with illustrations of a large number of installations of this equipment in industrial plants, in warehouses and for commercial work.—Standard Conveyor Co., No. St. Paul, Minn.

Bearings and Their Lubrication—A 40-page bulletin under the above title discusses this subject under the following headings: Bearing types, principles of the lubricating oil film, formation and maintenance of the lubricating oil film, characteristics of the lubricants, selection of lubricants, special examples of bearing lubrication, bearing trouble, and the benefits of correct lubrication. This bulletin is illustrated by drawings of different parts of mechanisms with the oil reservoir and path of the oil shown in color.—Vacuum Oil Co., 61 Broadway, New York City.

Paint Spray Troubles—A folder describes a special filter for use in paint spray booths to remove the paint before it enters the exhaust fan. These filters are placed between the operator and the exhaust fan and may be removed and cleaned when necessary.—Midwest Air Filters, Inc., 100 E. 45th St., New York City.

Welding and Cutting Apparatus—Catalog 172A lists, illustrates and describes the various Milburn cutting and welding torches, acetylene generators, preheaters and portable carbide lights, as well as other equipment.—The Alexander Milburn Co., Baltimore, Md.

Electrical Immersion Unit Heater.—Special electrical heating units of the embedded type, such as are used for the melting of Lavite and other salts which are used extensively for the tempering of tools, are described in recent literature. These units are placed inside of the pot containing the salt and are used to assist in bringing it to the high melting point.—Harold E. Trent, 259-261 North Lawrence St., Philadelphia, Pa.

Starting Switches for Small A.C. Motors—Bulletin 1048 describes the Type ZO starting switches for small alternating-current motors. These are push-button-operated, oil-immersed, across-the-line, induction motor starters which have no-voltage, overload and phase-failure protection.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Automatic Starters for Synchronous Motors—Bulletin 799 devotes 20 well-illustrated pages to a discussion of the principles of operation, explanation of diagrams, record of performance, protective features, source of actuating current, special features, rating, construction details and application of this type of apparatus.—Electric Machinery Mfg. Co., Minneapolis, Minn.

Synchronous Motors in Pulp and Paper Mills—Bulletin 875 devotes eight pages to such use of synchronous motors, describes their construction and operation and lists a number of applications.—Electric Machinery Mfg. Co., Minneapolis, Minn.

Boxes, Baskets and Trucks—A special catalog describes a lightweight box or basket constructed of smooth elm wood slats woven together with strands of wire for the sides for

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handling material in the shop or warehouse. These boxes are reinforced at the edges with heavier wooden strips and at the corners with metal. Casters may be added for trucking. The boxes are constructed so that they may be repaired if necessary.—D. B. Lewis Co., Watertown, Wis.

Electric Drill—A series of folders describes the four different sizes of Super Hole Shooter which are made to take drills up to ¼ in., 5/16 in., ½ in. and ⅝ in. This has a universal-type motor which may be furnished for either 110, 220 or 32 volts as specified. It will operate on 25-, 40- or 60-cycle alternating current. This drill also automatically blows the chips away. The folders give other advantages claimed for this equipment and also list a number of accessories, such as emery and polishing wheels, drill stands and so on. These four sizes of drill are designed to operate at speeds of 1,800, 1,400, 600 and 450 r.p.m., respectively.—Milwaukee Electric Tool Corp., Milwaukee, Wis.

Switchboards, Panel Boards and Special Electrical Apparatus—A catalog describes some of the various lines of special products manufactured by this company, such as Shockpruf panel and switchboards, relays, remote control switches, watertight floor receptacles, power wall receptacles, special equipment for alarm systems and other electrical specialties.—Butte Electric & Mfg. Co., 956 Folsom St., San Francisco, Calif.

The Dragon—A monthly house organ which is published under the above name in the interests of the Fafnir Ball Bearing Co., describes in an interesting way some of the installations of Fafnir bearings. The May issue describes the ball bearing mountings in a motor and in a woodworking machine application.—The Fafnir Ball Bearing Co., New Britain, Conn.

Arc Welder—A folder describes the Hansen arc welding generator which needs no stabilizing device to assist the operator to strike and maintain the arc. A description is also given of the Hansen-Oesterlein process of welding squirrel-cage rotors.—Northwestern Mfg. Co., Milwaukee, Wis.

How to Select Good Lubricants—A 52-page booklet under the above title is offered as an aid to the purchaser of lubricating oils and greases in choosing the grades that will help toward developing maximum efficiency in power equipment.—Dearborn Chemical Co., 310 So. Michigan Ave., Chicago, Ill.

Portable Electric Sander—A circular describes the Barker portable electric sander and grinder which uses sand paper or emery cloth on a wheel revolving at 4,000 r.p.m for finishing flat surfaces, or for removing varnish or paint from old surfaces before refinishing. This sander is operated by a 1/3 hp. motor.—R. L. Barker & Co., 642 W. Washington Blvd., Chicago.

Arc-Welded Building—Folder 4657 describes tests made of welded joints, the results of which led to the erection of a 40-ft. by 60-ft., one-story steel building from steel salvaged from the scrap pile. An interesting comparison is made in this folder of the erection cost of arc-welded buildings with that of riveted buildings.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Rubber Tile for Floor—A folder describes the Wright rubber tile and gives directions for laying it. This is used for special floors and for stair treads.—Wright Rubber Products Co., Racine, Wis.

Tumbler Type Motor Starting Switches—A small folder describes this equipment for use on fractional horsepower motors and heavy lighting circuits.—Trumbull Electric Mfg. Co., Plainville, Conn.

Fractional Horsepower Repulsion-Induction Motors—A circular describes the Type RF repulsion-induction motors with ratings of 1/6, ¼ and ½ hp. These are made for 60-, 50-, 40- or 25-cycle operation.—The Robbins & Myers Co., Springfield, Ohio.

Convertible Power Panel—A folder describes the Square D convertible power panel which provides a simple and easy means for adjusting at any time the spacing of the fuse jaws to provide for 30-, 60- or 100-amp. fuses, as may be required by changing conditions. The new voltage tester which requires no lamp is also illustrated in this folder.—Square D Co., Detroit, Mich.

Vacuum Cleaner for Industrial Plants—Bulletin 1030 describes the portable No. 5 double utility vacuum cleaner, which may also be operated as a blower, and its use in industrial plants for cleaning machinery by either suction or blowing. This cleaner is mounted on three wheels and transported by a handle like a truck.—The B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Electric Hoists for the Iron and Steel Industry—The 40-page Bulletin 80 describes the use of Shepard electric hoists, illustrates the different types of equipment, and shows some of the many applications possible in the iron and steel industry. In addition to the trolley, cage-operated, crane trolley, monorail hoists, and several special hoist applications, back-geared motors and speed reducers as well as industrial winches are included.—Shepard Electric Crane & Hoist Co., 415 Schuyler Ave., Montour Falls, N. Y.

Ventilating Apparatus—A pocket-size catalog, 11th edition, discusses Autovent propeller fans and blowers for ventilation.—Autovent Fan & Blower Co., 730-738 West Monroe St., Chicago, Ill.

Glue and Solder Pots—A folder discusses and describes automatic electric glue pots of 2-, 4- and 8-quart capacities, which automatically maintain a temperature between very narrow limits, and solder pots of 15 or 30 lb. capacity, which are made for operation on alternating or for direct current and automatically keep solder, babbitt, white metal or wax at a predetermined temperature.—Automatic Electric Heater Co., Warren, Pa.

Automatic Start Motors—Announcement is made of a new automatic self-starting, ball-bearing motor with no moving parts in the starting mechanism. This is a simple squirrel-cage motor with an improvised squirrel-cage rotor so designed that when the current is first thrown on it is carried in part of the cage until the motor attains its speed. At this point through magnetic or inductive action the complete squirrel-cage takes the load. These motors are made in ratings from 1 to 50 hp. inclusive.—U. S. Electrical Mfg. Co., 200 E. Slauson Ave., Los Angeles, Calif.

Extension Reel—A folder describes the Reelite and its uses with drop cords, on machine tools and for other purposes.—Appleton Electric Co., 1718 Wellington Ave., Chicago, Ill.

Solderless Connectors—Catalog 20 gives price list, code words, dimensions and other useful information about the Dossert solderless connector for standard and solid wires, rods and tubes.—Dossert & Co., 242 W. 41st St., New York City.

Gears—Catalog 46 gives directions for ordering gears, with lists and prices of various gears, pinions, pinion rods, herringbone, internal, miter, spiral, worm and bevel gears, sprockets and silent chains and the Boston speed reduction units, which consist of herringbone or worm reduction gear sets.—Boston Gear Works Sales Co., Norfolk Downs, Quincy, Mass.

Collar Oiling Bearing—Bulletin 112 describes the Cleveland type collar-oiling bearing, which is a positive oil feed distributing system. Instead of using a loose ring or chain for conveying the oil to the journal, a fixed collar is employed, which provides a positive means of elevating the oil from the reservoir in the bottom of the bearing. The bulletin also contains descriptions of hangers and pillow-blocks.—The Hill Clutch Co., Cleveland, Ohio.

Double-Worm Speed Reducer—Recent announcement is made of a new type of speed reducer in which two worm gears are used to give high reduction ratios, such as are required on conveyors and other similar equipment.—Foote Bros. Gear & Machine Co., 236-246 North Curtis St., Chicago, Ill.

Supports for Overhead Equipment—A folder describes the Midwest steel stringers and box rails which may be installed in buildings with reinforced concrete or mill-constructed ceilings, or attached to I-beams. With these attachments lineshafts, motors and other equipment may be attached to the ceiling easily and economically.—Midwest Steel & Supply Co., Inc., 100 E. 45th St., New York City.

Saving from 40 to 60 Per Cent of Handling Cost—A 36-page illustrated booklet under the above title describes the Cowan system of materials handling and shows by examples taken from a number of plants the savings which have actually been made in particular installations.—Cowan Truck Co., Holyoke, Mass.

Roller Hanger Bearings—A 24-page booklet entitled, "Facts About the Dodge-Timken Roller Hanger Bearing," gives a short account of the history of the Dodge Mfg. Co., and The Timken Roller Bearing Co., with a description of the Dodge-Timken roller hanger bearings and how they are made.—Dodge Mfg. Co., Mishawaka, Ind.

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INDUSTRIAL ENGINEER

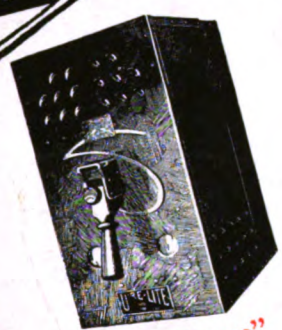
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

September, 1925

McGraw-Hill Co., Inc.
Chicago, Ill.

First to the left
Then to the right
Turn the handle
and U-RE-LITE



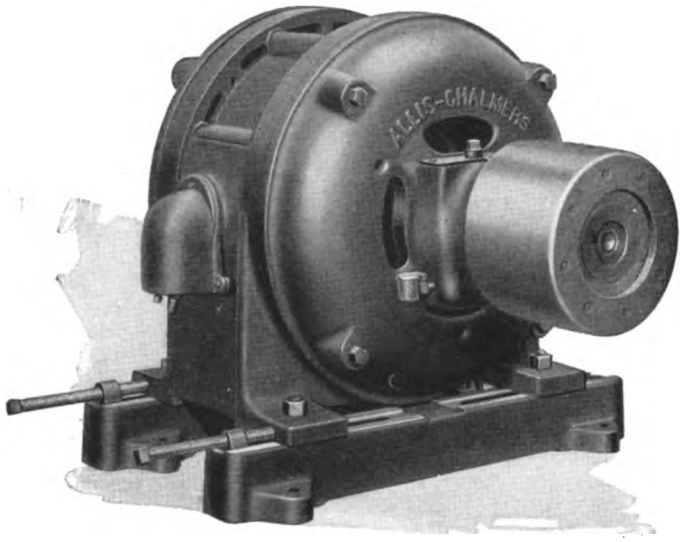
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Volume 83 Number 9

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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JAMES H. McGRAW, JR., *Vice-Pres.-Treas.*

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G. A. VAN BRUNT, *Managing Editor*

Housekeeping in a Factory

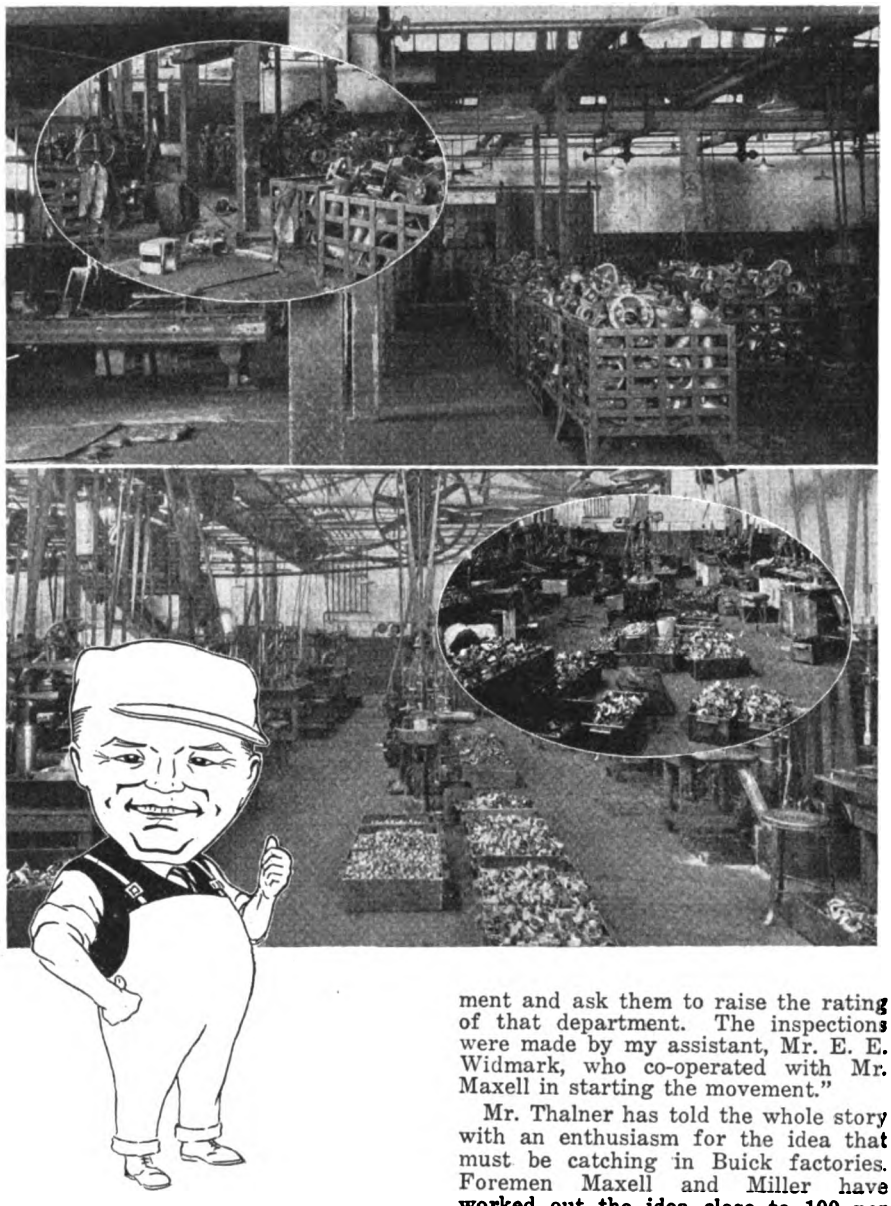
With Some Sidelights on How They Do It in the Shops of the Buick Motor Company

A SHORT while ago I was looking through a copy of the *Buick News*, a house organ which is marked, "Published in the interests of the entire Buick family." And so it is, for in that particular issue a double page of pictures showed what Buick foremen are doing to aid production through an organized program of keeping things in order about the shops they are responsible for. Good housekeeping in a large factory is just as much a family affair as in the home, and with a little co-operation all along the line the job is an easy one for all, and brings results that are pleasantly surprising. Just take a look at the accompanying pictures—they tell a real story.

I secured these pictures by writing to R. F. Thalner, safety director for the Buick Motor Company, at Flint, Mich., and with them came the following letter:

"The names of the foremen in the two departments which you asked about are Nottingham and Miller. These men are in charge of the departments as shown in the layout of the *Buick News*. The additional photographs which I am sending are from Mr. Maxell's department, who was the first foreman to initiate this campaign. If any mention is given, we desire to have his name used, inasmuch as he really started the ball rolling and created the competition among the other foremen. The general plan of procedure in this housecleaning campaign was to become familiar with the general conditions, and have pictures taken of the department in which the cluttered-up conditions showed up the worst.

"It was easy to sell the foreman on keeping the department clean for these reasons: It would give him a certain amount of floor space that he had never been able to use; it would allow him to pile his stock in an orderly condition; and it would make it a great deal easier for men and materials to move around the department. After the department was put in order, another picture was taken showing the improvement made. Both pictures were then posted in the department so the men might see the difference.



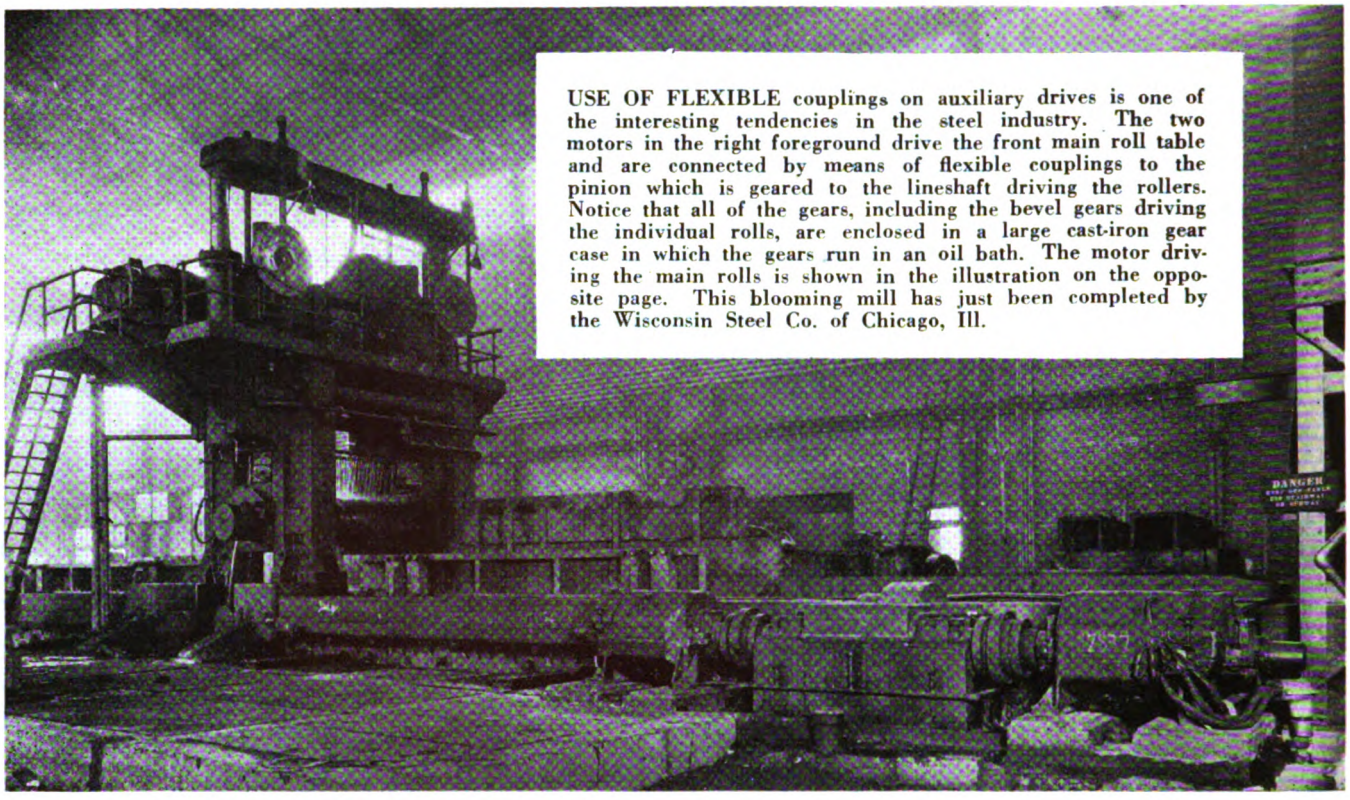
"As the experiment that started in Mr. Maxell's department has grown to such astonishing proportions, Mr. C. E. Hendricks, superintendent of plants 31, 32, 33 and 38 suggested that we start using a score card, with a passing score of 70 and a perfect score of 100. The carrying out of this suggestion has created more enthusiasm and friendly rivalry among the foremen and has been a stimulus for keeping the movement under way. In addition to the score card, a report was sent to L. D. Parker, manager of these factories, advising him of the standing of the various departments. He was then able to consult with his superintendents regarding the low standings of any particular factory or department and ask them to raise the rating of that department. The inspections were made by my assistant, Mr. E. E. Widmark, who co-operated with Mr. Maxell in starting the movement."

Mr. Thalner has told the whole story with an enthusiasm for the idea that must be catching in Buick factories. Foremen Maxell and Miller have worked out the idea close to 100 per cent, as shown in the accompanying pictures taken before and after the cleaning up, but that is not all. Foremen Brazill, Fisher, McRoe, Casey, Scranton and Heller and, by this time, probably several more are among those on the honor roll in factories 31 to 38 for keeping their departments in a condition that looks good through the camera lens.

This is a worth-while program. What are you doing along a similar line?

Practical Pete

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USE OF FLEXIBLE couplings on auxiliary drives is one of the interesting tendencies in the steel industry. The two motors in the right foreground drive the front main roll table and are connected by means of flexible couplings to the pinion which is geared to the lineshaft driving the rollers. Notice that all of the gears, including the bevel gears driving the individual rolls, are enclosed in a large cast-iron gear case in which the gears run in an oil bath. The motor driving the main rolls is shown in the illustration on the opposite page. This blooming mill has just been completed by the Wisconsin Steel Co. of Chicago, Ill.

New Trends and Recent Progress in Solving

Problems of Steel Mill Operation

That Involve the Use of Electrical and Mechanical Power-Drive Equipment, Together with Tendencies in Power Generation, Distribution, and Application

By ARTHUR J. WHITCOMB

Associate Editor, Industrial Engineer

TO AN even greater extent than usual, this past year has been marked by a replacement of existing steam engine drives with modern electrical equipment. This has been brought about by severe competition due to lack of foreign markets and to an excess of steel-making capacity. To meet competition, operators have been striving in every possible way to reduce operating costs and replacement of engine drives with electrical equipment has been one way of lowering these costs. It is interesting to note that out of 95,225 hp. in motors reported by one electrical manufacturer as sold during the year, 13 units totaling 23,750 hp. or approximately 25 per cent of the total represents motors that were purchased to replace existing steam engine drives.

One of the most radical change-overs from steam to electric drive in the history of the steel industry is to be made by the Colorado Fuel & Iron Company at its Minnequa Works, Pueblo, Col. Complete electrical equipment will be furnished for replacing the engine drives on a rod mill, a 10-in. merchant mill, a 14-in. merchant mill and a rail mill. The sizes of these drives are listed in the accompanying table. Five of these drives are direct-current, adjustable-speed motors, which are supplied from rotary converters.

The induction motor still meets, in some of its several forms, most requirements for main roll drives, except for reversing duty, where the direct-current machines with generator and motor field control continue to hold sway. Most induction motors now used are of higher speeds and are geared to the main roll drives. Gear reduction units have reached a high degree of reliability and efficiency, and their use in this connection with induction motors is becoming almost universal, as may be seen from the table shown on page 408.

The growing demand for high-tonnage mills with great flexibility in range of product is, however, requiring more and more adjustable-speed, direct-current motors which in turn is giving more importance to the question of whether motor-generators, rotary converters or mercury arc rectifiers should be used for

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transforming from alternating to direct current.

For certain types of mills synchronous motors for driving the main rolls have been considered very favorably by many of the operators interviewed. At one plant visited an unusually large installation was considered for a piercing mill, while at another plant synchronous motors were contemplated for use on cold rolls. Several installations have been made in some tube rolling and piercing mills. However, the motors used are 1,000 hp. or less in rating. Just recently a 9,000-h.p. synchronous motor has been purchased by the McKinney Steel Company for direct connection to a Morgan continuous billet mill at its River Furnace plant in Cleveland, Ohio. The motor will have a shaft extension on both ends and will be coupled to a long lay shaft running the length of the mill, with bevel gearing to each of the ten roll stands. This is said to be the first large steel rolling mill in the world to be driven by a synchronous motor. In fact, the motor with its rating of 9,000 hp., 107 r.p.m, 6,600 volts, three phase, 25 cycles, is reported to have the highest continuous horsepower rating of any industrial motor in the world.

The motors driving two reversing blooming mills, one in the Pittsburgh district and the other in the Chicago district, are rated at 7,000 hp. and built with a single motor armature which is supplied from two generators in parallel, forming part of a three-unit set. This is a distinct departure from the usual practice of having several armatures connected in series where units of this size are involved. One of these drives is illustrated on this page. Physically, these 7,000-hp. motors are said to be the largest single-armature, reversing motors yet built. However, a similar unit of 8,000-hp. rating is now under construction for use in a 54-in. blooming mill in the Pittsburgh district. This blooming mill is the largest mill of the kind in the country and likewise its driving motor will upon installation be the largest of its kind.

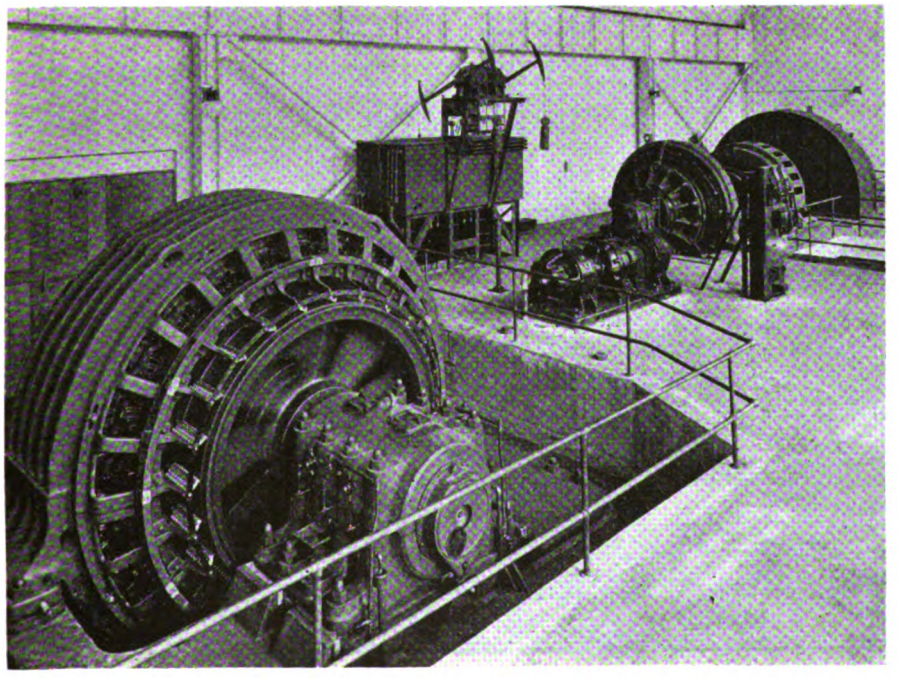
EVERY TWELVE MONTH period shows a steady and truly remarkable increase in the application of electricity to the manufacture of iron and steel. The current year has been no exception. Generally speaking, the growth has been along lines that are already well defined and presents little that is fundamentally new. However, there have been many refinements made in the application of electric power, larger capacities of equipment have been used or are contemplated and various other events which go to make the progress accomplished during the year an interesting story. The information presented in this article has been gathered by visits to many of the steel plants in the different steel mill districts, and from interviews with a large number of steel mill engineers and superintendents who are responsible for the maintenance and operation of power-drive equipment. In this article details are given of new developments in the use and application of such equipment and the lines along which men responsible for plant operation are thinking.

Besides the reversing blooming mill drives just mentioned, and the 9,000-hp. synchronous motor for the McKinney Steel Company, another largest motor of its kind is the Kraemer set recently purchased by the Youngstown Sheet & Tube Company for a 21-in. continuous sheet, bar and skelp mill. The induction motor of this set is rated at 7,500 hp. and regulating equipment is provided for adjusting the speed from 250 to 134 r.p.m.

A new type of double range Scherbius drive, apparently the first of its kind, will be installed by the Trumbull Steel Company in its 16-in. hot strip mill. The set is rated at 5,000/4,000/3,000 hp., 450/360/270 r.p.m. The unusual feature of the set lies in the regulating set, which will consist of two machines each rated at 480 kva., 514 r.p.m., a synchronous motor rated at 1,175 hp., 514 r.p.m., and an 18 kw. exciter for supplying excitation to the synchronous motor field. The synchronous motor will replace the usual induction motor, thus providing operation at the maximum possible power factor. The two regulating machines allow a higher speed to be used for the set, each unit being one-half the required capacity. A further advantage is that, by the use of this equipment, a much lower secondary current is developed in the main motor, permitting the use of smaller contactors and resistors of lower current capacity, making the installation work less difficult.

Should it be necessary to remove one regulating machine from the group, the electrical circuit to that unit can be removed and suitably connected; three of the collector rings will be shorted and the equipment will operate with one regulating machine, one-half the total regulation being thus obtained both above and below synchronous speed.

Another interesting development brought out by one manufacturer is the frog-leg winding for direct-current machines, which is said to remove the previous limitations on these machines due to difficulties of



Largest single armature reversing motor that has been installed up to the present time.

The installation of this 7,000-hp. reversing motor has just been completed at the new blooming mill of the Wisconsin Steel Co., which is shown on the opposite page. The single armature motor at the left is supplied with 600-volt direct-current power from two generators in parallel forming part of the three unit flywheel motor-generator set shown at the right.

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commutating heavy or rapidly fluctuating loads, and now enables them to offer machines which are reported to have commutating qualities beyond anything previously built.

An interest in dry-type air cleaners for use in cleaning the ventilating and cooling air for main drive motors, was expressed by some operators. So far, wet washers have been used almost exclusively for this class of service.

Changes in Auxiliary Drive Equipment

The use and application of auxiliary motors for steel mill service has been almost standardized. There is, however, a distinct tendency to use synchronous motors wherever possible on auxiliary drives requiring constant speed. This has been caused by a desire to improve power factor conditions or to maintain the good power factor that the plant happens to enjoy. To meet this demand synchronous motors with improved starting and operating characteristics have been developed.

Continued interest is expressed in ball and roller bearings not only for auxiliary motors in the mill, but on other parts of the drive. One of the pioneers in the use of ball and roller bearings in steel mills now has 314 sets of these bearings in operation. It is said that this large installation is cutting down the man-hours required for maintaining the motors, as well as showing a saving in oil and repairs over former requirements.

A plant in the Pittsburgh district in purchasing motors for a new mill had the majority of the mill-type motors equipped with roller bearings. Another plant visited was considering the installation of roller bearings on all of the bearings of some cranes that were about to be contracted for. An installation of roller bearings was made on the conveyor belts in the coke plant in another works visited. This greatly reduced the starting torque required of the motors driving these belts, as well as cutting down on the oiling costs. Most steel plants, however, are putting in ball or roller bearings as a repair proposition wherever service conditions or bearing troubles show a need of them.

On the other hand several operators interviewed stated that more attention should be given to improving the sleeve bearing and in using

Motor-Driven Main Drives Purchased During Past Year

Company	Mill	Drive	Motors No.	Motors Hp.	Volts	Cycles	R. P. M.
Acme Steel Goods Co.	20-16-in. Strip	Geared	1	1500	2200	60	705
	20-16-in. Strip	Geared	1	1500	600	dc	200/400
	20-16-in. Strip	Geared	1	1800	600	dc	185/370
	20-16-in. Strip	Direct	1	1800	600	dc	185/370
	20-16-in. Strip	Direct	2	1800	600	dc	125/250
Bethlehem Steel Co., Lackawana, N. Y.	35-28-in. Structural	Direct	1	3500	700	dc	50/120
	35-28-in. Structural	Direct	1	5000	700	dc	75/150
Carnegie Steel Co., Homestead, Pa.	54-in. Blooming	Direct	1	8000	700	dc	40/120
	52-in. Structural	Direct	2	7000	700	dc	50/120
Connors Steel Co.	Hoop	Geared	1	800	2200	60	435
Gary Tube Co.	Seamless Tube	Geared	1	2500	6600	25	247
Inland Steel Co.	36-in. Rev. Rougher	Direct	1	7000	700	dc	50/120
Wisconsin Steel Co.	40-in. Blooming	Direct	1	7000	700	dc	50/120
	Merchant	Direct	1	3100	600	dc	70/150
	Merchant	Direct	3	2000	700	dc	230/460
Kokomo Steel & Wire Co.	34-in. Blooming	Direct	1	3500	700	dc	50/120
Lukens Steel Co.	112-in. Plate	Geared	1	3750	2200	60	500
National Tube Co.	Tube	Geared	1	1800	2200	60	252
Rail Joint Co.	20-in. Bar	Geared	2	1000	2200	60	710
Central Tube Co.	Pipe	Geared	1	300	230	dc	500
Ohio Seamless Tube Co.	Pipe	Geared	1	500	2200	60	600
Otis Steel Co.	Cold Roll	Geared	2	375	230	dc	430/860
Pacific Coast Steel Co.	10-in. Merchant	Geared	1	1500	2200	60	320/200
Carnegie Steel Co., Youngstown, Ohio.	12-in. Strip	Geared	1	1125	6600	25	312/187
	12-in. Strip	Geared	1	1500	6600	25	468/281
	12-in. Strip	Geared	1	2000	6600	25	625/375
	14-in. Bar	Geared	1	2000	6600	25	625/375
	18-in. Band	Geared	2	2500	6600	25	187½
	18-in. Band	Geared	1	2200	6600	25	275/225
Seneca Iron & Stee lCo.	Hot Sheet	Geared	1	1700	440	25	250
Buffalo Steel Co.	Rail Splitter	Geared	1	400	4400	25	750
Bethlehem Steel Co., Sparrows Point, Md.	46-in. Slabbing	Direct	1	7000	650	dc	50/100
	10-in. Rod	Geared	1	4000	6600	25	375
Kawasaki Dockyard, Japan.	Sheet	Geared	1	1200	2200	60	240
American Nickel Corp.	Cold Sheet	Geared	1	1000	2200	60	450
Youngstown Sheet & Tube Co., Indiana Harbor, Ind.	21-in. Skelp	Geared	1	3600	2200	60	290/156
	21-in. Skelp	Geared	1	7500	2200	60	250/134
	21-in. Skelp	Direct	3	2000	600	dc	85/165
Tennessee Iron & Coal Co.	Sheet	Geared	1	2000	6600	60	600
Inland Steel Co.	8-in. Continuous	Direct	1	1500	600	dc	50/80
	8-in. Continuous	Geared	1	1800	600	dc	200/400
	8-in. Continuous	Direct	1	800	600	dc	350/750
	Sheet	Geared	1	2500	2200	25	300
Colorado Fuel & Iron Co.	Rod	Direct	1	1500	600	dc	450/550
	Rod	Geared	2	3000	6600	60	450
	Rod	Geared	2	1000	6600	60	720
	14-in. Merchant	Direct	1	1500	600	dc	100/150
	14-in. Merchant	Direct	1	750	600	dc	150/250
	10-in. Merchant	Direct	1	1500	600	dc	200/300
	Rail Mill	Geared	1	2000	6600	60	450
	Rail Mill	Geared	1	3000	6600	60	450
	Rail Mill	Geared	1	1200	6600	60	450
Inland Steel Co.	24-in. Bar	Direct	1	3000	750	dc	70/150
McKinney Steel Co.	Continuous Billet	Direct	1*	9000	6600	25	107
Bethlehem Steel Co., Steelton, Pa.	28-in. Rail	Geared	1	4000	6600	25	375
	35-in. Rail	Direct	1	3500	650	dc	50/100
Trumbull Steel Co.	16-in. Hot Strip	Geared	1	5000	2200	60	450/270
Thomas Sheet Steel Co.	Cold Rolls Sheet	Geared	1	400	2300	60	360
Otis Steel Co.	Jobbing Plate	Geared	1	2000	2200	25	214
International Nickel Co.	Cold Rolling	Geared	1	750	230	dc	300/600
Kansas City Bolt & Nut Co.	Sheet Mill	Geared	1	1500	2200	60	295
Gary Tube Co.	16-in. Skelp	Geared	1	350	230	dc	500
	16-in. Skelp	Geared	1	550	6600	25	370
	16-in. Skelp	Direct	1	2500	6600	25	295
	16-in. Skelp	Direct	1	2500	6600	25	146
	16-in. Skelp	Direct	1	3000	6600	25	184
	14-in. Skelp	Geared	1	1500	6600	25	491
	14-in. Skelp	Geared	1	1000	6600	25	293
	14-in. Skelp	Geared	1	2000	6600	25	294
	14-in. Skelp	Direct	1	1250	6600	25	294
	14-in. Skelp	Direct	1	1000	6600	25	209
Bethlehem Steel Co., Johnstown, Pa.	18-14-in.	Geared	2	3000	250	dc	150/300
	18-14-in.	Geared	2	1500	250	dc	150/300
Bethlehem Steel Co., Buffalo, N. Y.	18-14-in.	Direct	1	3000	250	dc	150/300
	18-14-in.	Direct	1	1500	250	dc	150/300
Bethlehem Steel Co., Johnstown, Pa.	12-10-in.	Geared	1	2000	250	dc	200/600
Johnstown, Pa.	12-10-in.	Geared	1	1700	250	dc	250/500
	12-10-in.	Direct	1	900	250	dc	425/640
	12-9-in.	Geared	2	1000	250	dc	200/480
	12-9-in.	Direct	1	500	250	dc	250/600
American Sheet & Tin Plate Co.	Steel	Geared	1	1250	6600	25	300
Gary Tube Co.	Skelp	Direct	1	4500	750	dc	120/255
Indianapolis Steel Casting Co.	Bore		1*	500	2200	25	450
National Tube Co., Lorain, Ohio.	Piercing	Geared	1*	1000	6600	25	375
	Piercing	Direct	1*	800	6600	25	107
Phoenix Iron Co.	36-in. Blooming	Direct	1	3500	700	dc	50/120
Youngstown Sheet & Tube Co., Youngstown, Ohio.	Seamless Tube	Direct	1	3000	600	dc	40/100
	Seamless Tube	Geared	3	650	600	dc	225/400
	Seamless Tube	Direct	1	3000	600	dc	125/200

*Indicates Synchronous Motor.

For drives purchased prior to Aug. 1, 1924, see page 410, of the September, 1924, issue of Industrial Engineer

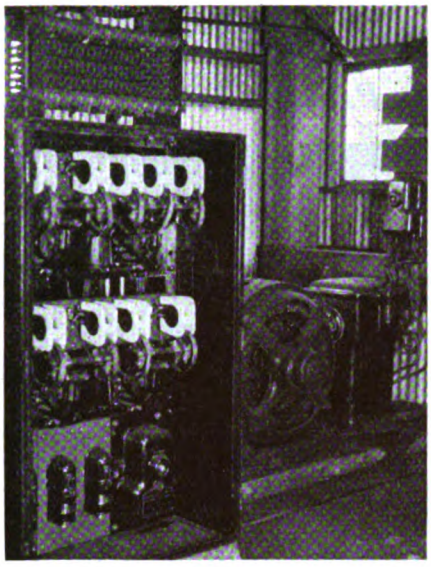
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the correct grade of bearing metal properly heated and poured. Some of them felt that a great deal of the trouble experienced by some operators was due to poor workmanship in making their bearings in their own shops. The leading motor manufacturers have made radical improvements in the sleeve bearings used in their motors, which are said to greatly reduce the oil troubles that have been experienced.

Use of Flexible Couplings on Auxiliary Drives

An interesting tendency is noted in the greatly increased use of flexible couplings on steel mill auxiliary drives. In a new blooming mill in the Chicago district, flexible couplings were used on practically all of the auxiliary drives. These couplings were not used on the cranes, however. In new mills at one plant in the Pittsburgh district, the engineer interviewed stated that 80 per cent of the auxiliary drives were equipped with flexible couplings. In a new blooming mill in this same district, the operator talked with said that flexible couplings were used in every possible case.

Several reasons were advanced by the superintendents interviewed for the adoption of these couplings. The electrical superintendent of one plant visited stated that he had decided to use the flexible couplings because he was thereby able to do away with back-geared, mill-type motors and thus keep all of the gears in one housing instead of two, as well as reduce the number of types of motor frames required. Reasons advanced by other engineers interviewed are: the reduction of gear shock on the motor and the insuring of proper alignment of motor pinion and driven gear.



Here is a newly developed automatic starter for a synchronous motor.

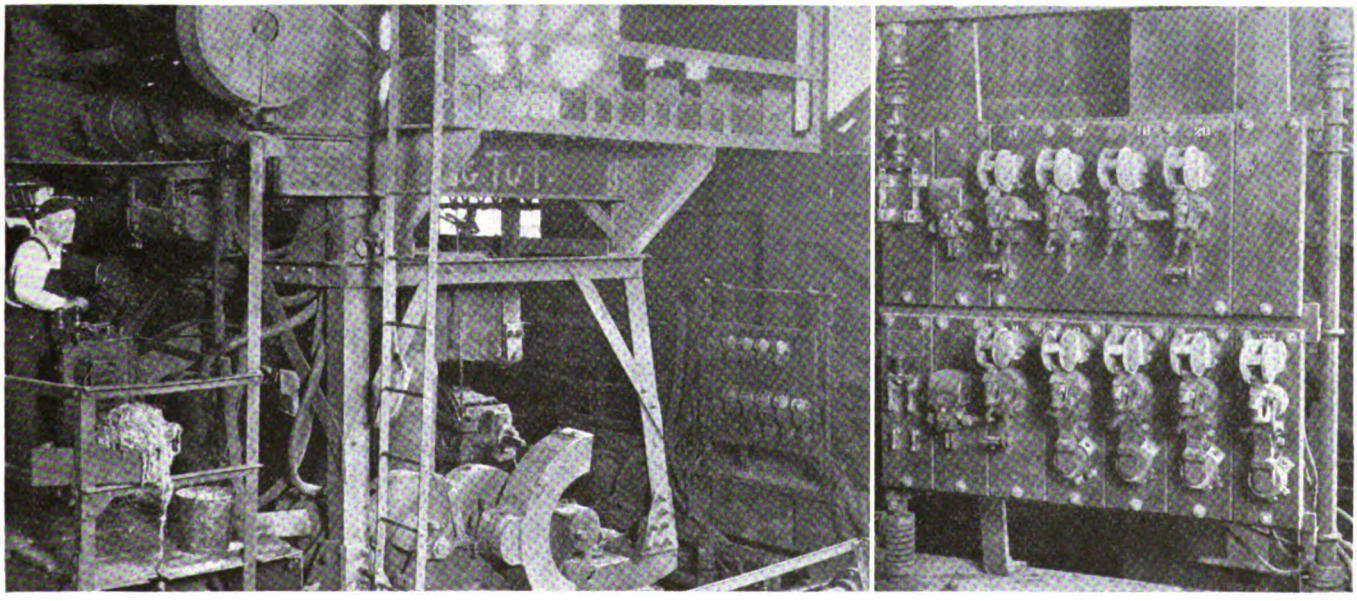
The direct-current field excitation is automatically applied under the control of a timing relay after the motor has been accelerated almost to synchronous speed. Two sets of overload relays are used; one set, which is set for tripping at a lower current, disconnects the magnetic clutch between the motor and the drive and the other set disconnects the motor from the line.

The increased use of time-limit acceleration on auxiliary control is an interesting tendency.

The controller on the bridge motion of this soaking pit crane controls two 50-hp. motors in series. Inductive time-limit acceleration is used. The control panel is mounted on the bridge end-girder in the right background. A close up view of the panel is shown at the right. The first four contactors at the right in the lower section of the board are the accelerating contactors. Notice that these contactors have two operating coils that oppose each other for the contactor armature is hinged between the two coils. The function of these coils is described in the accompanying article.

Decidedly more attention is being paid to the gears used on not only the large gear reduction units for main drives, but also on the large number of gears used for the auxiliary drives throughout the plant. Gears as used in auxiliary drives are following the developments that have been made in the large-capacity gear reduction units. In place of the sheet-iron cover and the use of heavy grease on the gears of auxiliary drives we find many of them totally enclosed in oil-tight, cast housings. The gears run in oil and force-feed lubrication is often provided. The use of heat-treated gears and pinions is increasing. Several plants visited maintain their own heat-treating departments. The use of herringbone gears on auxiliary drives has been considered and in one instance has been tried.

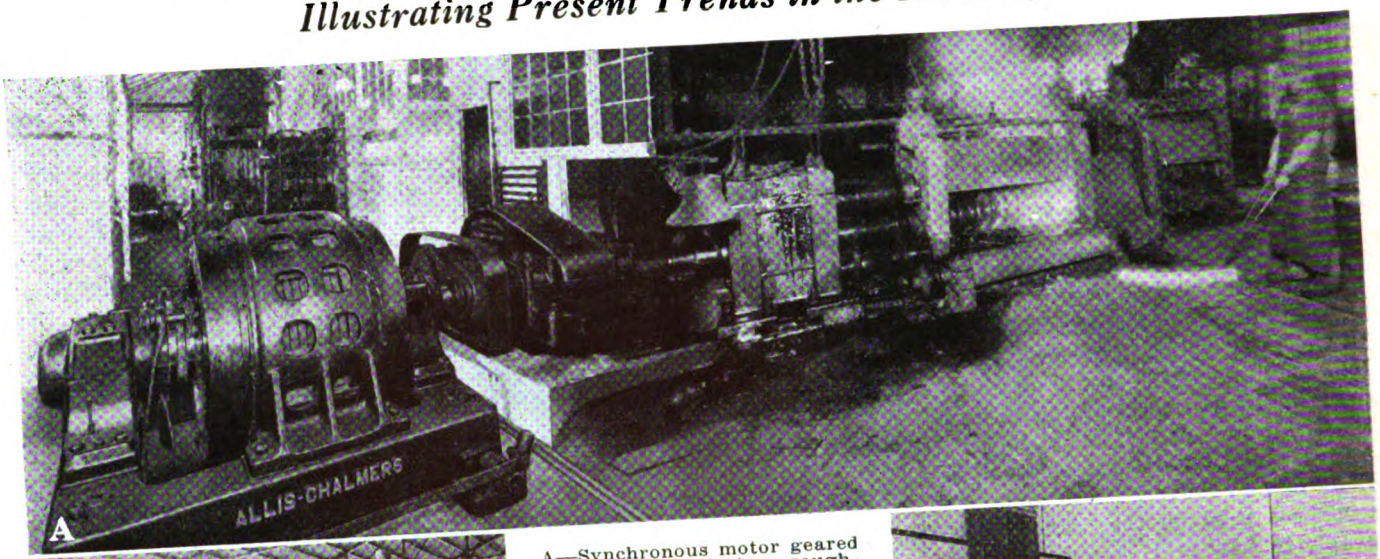
An increase in the use of speed reducers in steel mills was also noted. These have found greatest application on various kinds of conveyors, such as pipe conveyor chains, small roll conveyors, pipe pushers and the like. One operator stated that he was using them because they were very compact and would fit into crowded quarters, are totally enclosed, well lubricated and he expected them to have a long life with small maintenance. An engineer in the Chicago district was using them because the space he had available was very cramped and he needed a tightly-enclosed reduction because of the dirty location.

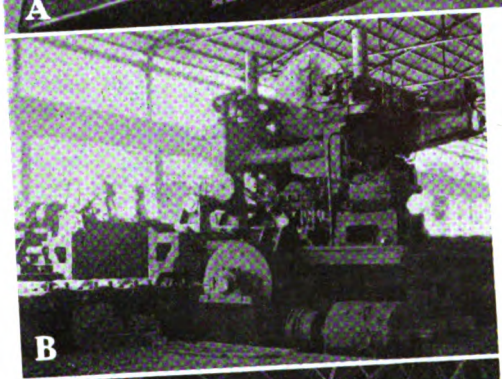


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Seven Applications of Power Service in Steel Mills

Illustrating Present Trends in the Industry







A—Synchronous motor geared to the main rolls in a roughing mill of the Atchison, Topeka & Santa Fe R. R. The motor is rated at 500 hp. and has a speed of 450 r.p.m.

B—Flexible couplings are used on all of the auxiliary drives of this blooming mill recently completed by the Campania Cia Siderurgica Del Mediterraneo, Sagunto, Spain.

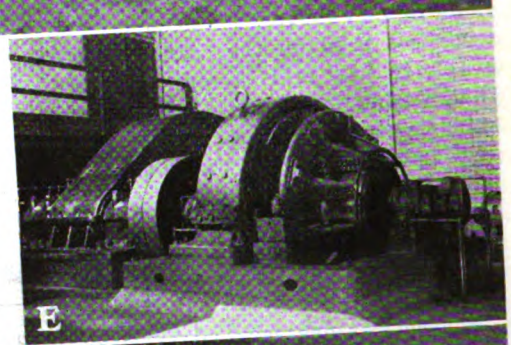
C—Truck-type switchboards are finding increased favor in steel mills. This one is installed in the plant of the International Nickel Co. at Huntington, W. Va.

D—Motor room of the new 40-in. reversing blooming mill at the Lackawanna plant of the Bethlehem Steel Co.

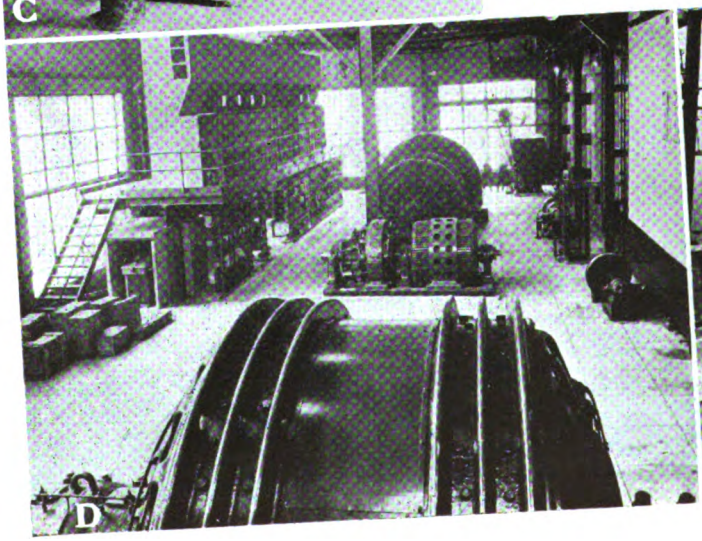
E—A 3,000-hp., 325/485-r.p.m., 600-volt, d.c. motor driving the 24-in. structural mill of the Phoenix Iron Co. through a herringbone gear reduction. The motor is supplied with d.c. power from a flywheel motor-generator set.

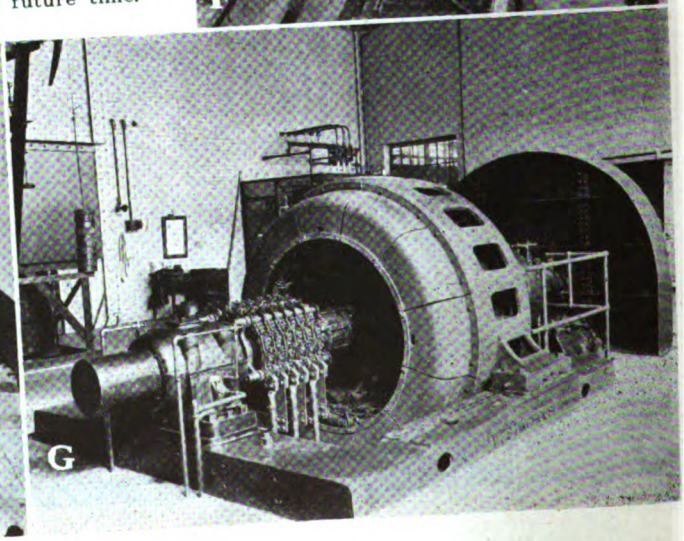
F—Automatic high-voltage compensators installed in the pump house of a steel plant.

G—A 2,500-hp., 514 r.p.m., wound-motor induction motor driving a 22-in. bar mill through a high-speed flywheel and a herringbone reduction gear, in the plant of the Phoenix Iron Co. This motor is arranged so that speed adjusting auxiliaries can be added at some future time.









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Development of control equipment for steel mill service is by no means at a standstill. Probably one of the outstanding trends is expressed in the keen interest displayed by many operators in time-limit acceleration. Current-limit acceleration has become almost an accepted standard form and many operators expressed satisfaction with its performance. However, the development of new types of time-limit devices has stimulated new interest in this form of acceleration.

Trends in Use and Installation of Steel Mill Control

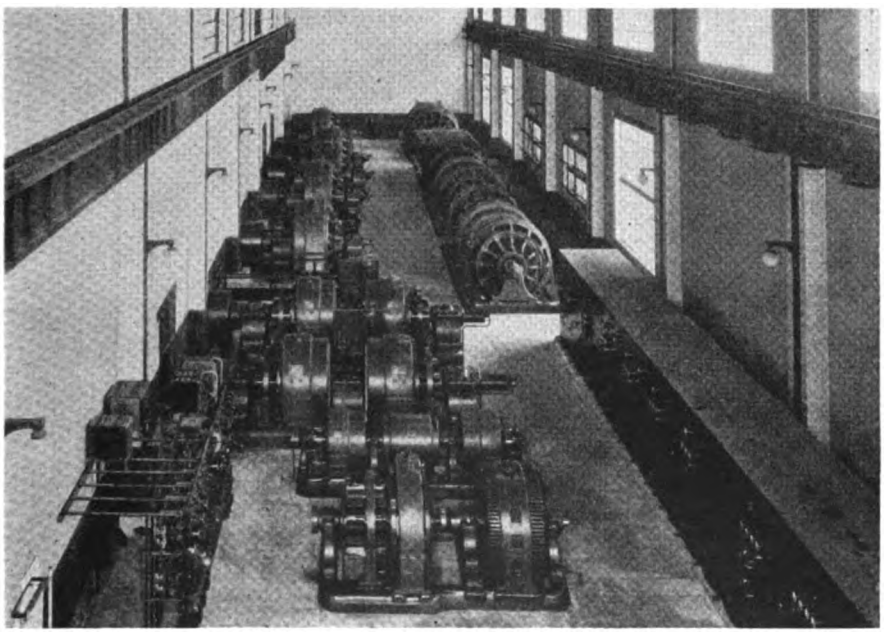
In one system the time interval between the closing of successive accelerating contactors is secured by an ingenious application of the well-known principle that when a constant, direct-current potential is applied to a circuit containing inductance, an appreciable time elapses before the current reaches its maximum value. On this particular type of control, the accelerating contactors have both a shunt closing coil and a shunt holding-out coil, both of which act upon the same armature, as is shown in the right-hand illustration at the bottom of page 409. On the back of the controller is mounted a transformer having two series windings, the motor being connected to the middle or common point. The motor connections are so arranged that for each successive accelerating point, one or the other of these windings serves as the primary and the main motor current passes through this coil. The connections are arranged so that the coil which does not carry the motor current is connected to the holding-out coil on the next accelerating contactor, and by adjusting the air gap on the accelerating contactor, the time of closing can be varied between definite values which depend on the stored energy in the magnetic circuit of the transformer, the design of the holding-out coil, and the adjustment of the contactor air gap.

This form of time-limit acceleration is known as the inductive type. Another form, known as the magnetic type secures the time element of acceleration by the delay in building up or down of a magnetic field. When the relay coil is short-circuited, a definite time is required for the flux to decrease to a point permitting the release of the relay armature. This armature is forced out by a spring of adjustable tension which, together with other features, gives a timing range of 0.2 to 2.0 seconds. Once adjusted, this timing is said to remain constant under all operating conditions. Current-limit is provided for plugging when reversing, while the time-limit is used for acceleration.

In talking with many steel mill operators it was found that several installations of both types had been made, which are being watched with great interest.

Truck-type switchboards are finding increased favor in many steel plants.

This type of switching is used for the alternating-current end of 13,500 kw. in synchronous motor-generator sets in the recently completed 14-in. continuous mill of the Woodlawn Plant of the Jones & Laughlin Steel Corporation. In this same motor room there are 14,600 hp. in 600-volt, direct-current, main roll motors.



Another tendency lies in the arrangement of groups of the more important panels so that a spare panel may be switched into use in case a failure should take place on any panel in that group. Recent installations of this arrangement have been made by the Westinghouse Electric & Mfg. Co., the General Electric Company and the Cutler-Hammer Mfg. Co. A typical installation of this system at the Lackawanna plant of the Bethlehem Steel Company is shown in the illustrations on page 414. This group of panels controls the auxiliary motors for a 40-in. blooming mill. At the bottom of 11 of these panels are four-pole, double-throw switches that are used for transferring the motor circuits from the regular panels to the spare panel. A small drum switch is mounted on each regular panel, which is used to transfer the master switch circuits from the regular panel to the spare panel.

Another installation of this arrangement of control is shown on page 412. This installation consists of 20 panels. One panel serves as a spare for two regular panels controlling motors driving the manipulator lifts, a second panel serves as a spare for five other panels, including the main tables, sideguards and screw downs, while a third panel is a spare for the remaining nine panels. In the case of the last two spare panels just mentioned, the panels may be called upon to control either of two capacities of motors. This is taken care of by the multipole switch in the bottom section of the spare control panels. By manipulating this switch the resistors are connected in parallel to take care of the larger-sized motor.

With this type of installation, control trouble can cause a delay of only a few seconds, for the defective panel may be cut out and the spare panel put in service almost instantly.

At one plant this idea has been carried still further by using what is known as plug-type master switches. By loosening four wing nuts, a master switch may be removed and another one inserted in its place. A plug-type connection is used for connecting the master switch terminals to the wires leading to the control panel.

On the other hand, one engineer in discussing this subject with the writer stated that he did not favor this arrangement of control because

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in his experience control failures are very few and usually give ample warning of their approach. He felt that each controller should be selected and designed particularly for the application on which it is to operate, rather than use standard controllers on all jobs that were somewhat similar.

In order to cut down operating costs by reducing the number of men required, automatic operation is being used more and more. In the soaking pits of a new blooming mill in the Pittsburgh district, the control is so arranged that the soaking pit crane operator opens and closes the soaking pit covers, lifts out the ingot with his crane, places the ingot in the buggy and starts the buggy on its way to the transfer car. This eliminates the doorman and buggy operator formerly required. As the buggy approaches the point where it meets the transfer car it automatically slows down to a stop and if the transfer car is in place the ingot is automatically dumped into it. If the transfer car is not in place the ingot is held until the car arrives. At this same mill and also at another blooming mill nearing completion in the Chicago district, the large reversing motor driving the main rolls is controlled from a foot-operated master, thereby cutting down the number of men required in the pulpit from three to two.

In the blast furnace blower house of a large mill in the Chicago district this same thought has been carried out by using a centrally-located control point for all of the blast furnace turbo-blowers. The control consists of remote-controlled, motor-operated governors on the turbines and motor-operated valves. Control for three or more blowers is located at one place so that they may be controlled simultaneously by one engineer, thereby resulting in a reduction in the number of engineers required in the blower room. Special telephone connections are made from each blast furnace to this central control point. Verbal orders as to pressure, checking, and the like are telephoned to and executed by the one engineer.

More Substantially Constructed Control Houses

In all of the new mills visited a marked trend was noticed towards the more substantial housing of control equipment. The favored construction is to place the control in a centrally-located brick house adjacent to and overlooking the main part of the mill. In a new blooming mill in the Chicago district a two story brick enclosure is built just opposite the mill runout tables. The first story is used as a motor inspector's shanty and provides space for his tools, miscellaneous supplies, and spare equipment. It also provides a convenient location for bringing in the power lines and conduits coming from the auxiliary drives to the control panels which are located on the second floor. The panels are located in two rows facing each other with at least 5 ft. of room behind the panels so that a man may do any necessary repair work in comfort and safety. There is a large window so located in the wall that most of the motors out in the mill can be seen from the control house. Conduits to auxiliary motors go down through the floor. Power is fed to the panels from a bus located over the panels and under the resistor balcony. The resistors are placed in two balconies in rows at right angles to the panels and each resistor frame is so mounted that it may be removed from the stack without disturbing the others. Walkways are provided between the rows of resistors so that each resistor is accessible from either side. This arrangement of resistors is illustrated on page 413.

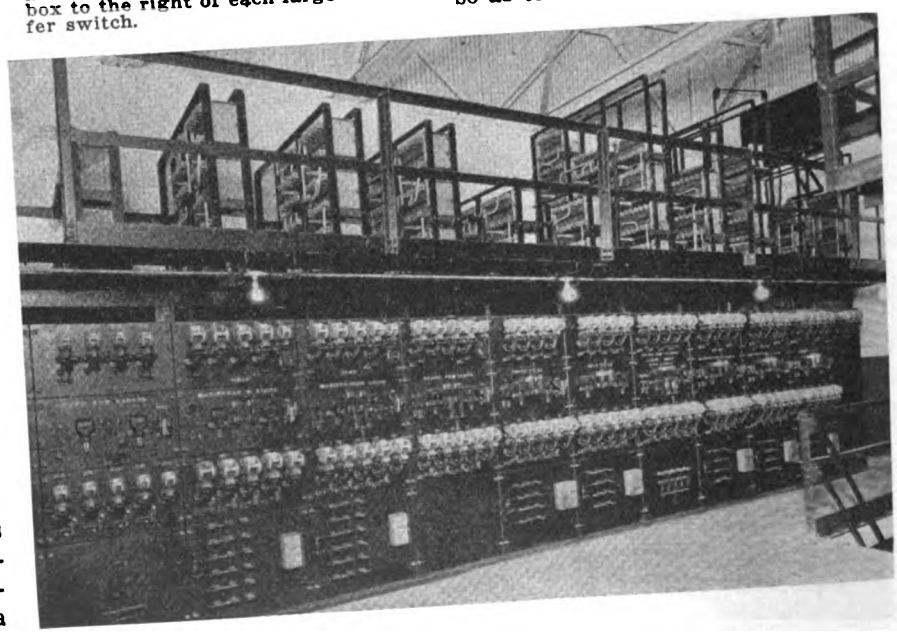
The idea behind the whole installation is that if a tight enclosure is provided, the operating conditions will be less severe and the maintenance much easier. Also, if all parts are accessible so that they can be reached in safety, the quality of inspection received will be much better. When a failure actually does take place it will be quickly corrected, inasmuch as the room and facilities are provided for making quick repairs or changes.

As mentioned before in this article, new uses and applications are being found for synchronous motors. Owing to this demand several manufacturers have developed automatic starters for use on these motors. Push button control is provided and the direct-current field excitation is automatically applied under the control of a timing relay after the motor has been accelerated almost to synchronous speed. An installation of this type of control is shown on page 409.

An interesting innovation was made in the control for the blast furnace pump motors in a large plant in the Cleveland district. These pumps are important applications and must at the same time have proper overload protection; hence they are connected direct to the power house bus so as to insure continuity of service.

Provision for quickly switching in a spare panel in an emergency is an innovation in several mills.

In this control house of the new blooming mill of the Wisconsin Steel Co., there are 20 panels arranged in two rows facing each other. One panel is a spare for two regular panels, a second panel is a spare for five other regular panels and a third panel (the one at the extreme left) is a spare for nine other regular panels. The spare panel at the left is arranged for two capacities of motors. Switching from one size to the other is obtained by the multi-pole switch at the bottom of the spare panel. This parallels sections of the resistance. Transfer of the main motor connections from the regular panel to the spare is effected by the large multi-pole switches in the bottom sections of the regular panels. The master switch circuits are transferred by means of the small switch in the box to the right of each large transfer switch.



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Because the ordinary compensator does not have sufficient rupturing capacity it was necessary to use oil switches of proper rupturing capacity in connection with each pump. This made the layout rather expensive.

To reduce the cost, and because the motors were seldom started and stopped, it was decided to use only one auto transformer. This is connected to the 2,300-volt supply by an oil switch. The auto transformer supplies low-tension starting voltage to a bus which is carried to each motor. Connecting this starting bus to each pump motor is a non-automatic oil switch that is used for starting duty only. The 2,300-volt supply is connected to each motor through an automatic oil switch equipped with overload relays. The starting and running switches have the usual mechanical interlocks and, in addition, interlocks are provided which prevent starting more than one motor at a time. This provides selective protection on each motor and eliminates the necessity of large auto-transformers for each motor.

The question of whether to use compensators or primary resistance starters on low-voltage, squirrel-cage motors is still a live one. One engineer interviewed stated that he was using only primary resistance starters, while others expressed a preference for automatic compensators. The general opinion, however, seems to be that there is a field for both; that some applications are more adapted to compensators while others are more suited for primary resistance starters.

A very interesting installation of about 1,500 enclosed circuit breakers has been made in one steel plant in the Chicago district. Every motor in the plant is given overload protection by means of an enclosed circuit breaker installed in its vicinity. An unusual feature is that the circuit breakers are made with removable elements. The leads coming to the circuit breaker are permanently connected to a terminal board which has contact blocks on the face of it which connect to the circuit breaker proper. The circuit breaker element is mounted on a separate panel which can be quickly removed by releasing the lever which holds the steel enclosing cover in place. Hence in case of a failure of a circuit breaker, replacement with a new circuit breaker element is merely a matter of seconds.

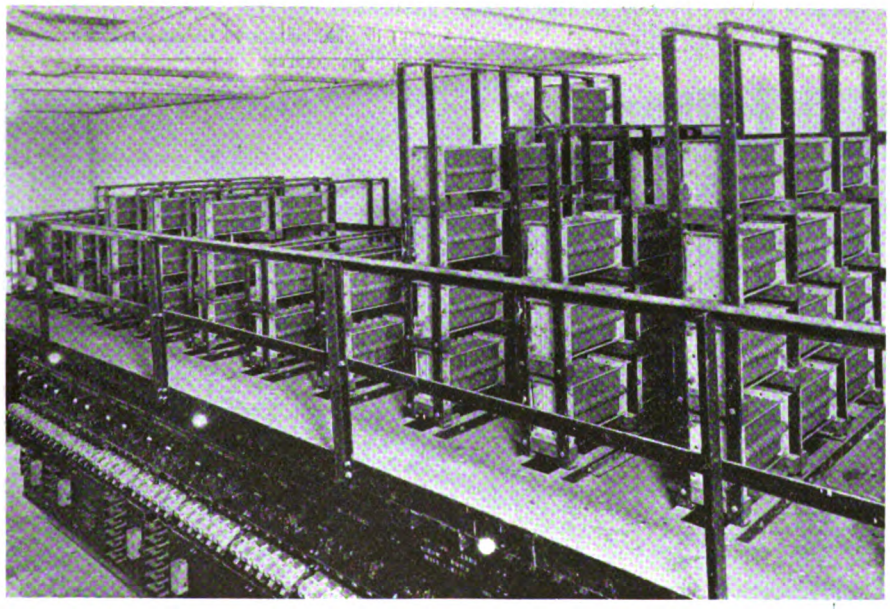
Reduction of spare parts by standardizing on types and sizes of resistor frames has been worked out exceedingly well in a new blooming mill in which only four different resistor frames are used.

Many operators expressed interest in a new type of resistor that has been recently developed. This resistor consists of a high-resistance alloy ribbon, wound on edge, and mounted on a steel-reinforced porcelain support that passes through the entire length of the unit. Two simple forms of clamps provide the facilities for making connections at the ends or at any desired point in the resistance.

Another new development that will be of interest not only to steel plant electrical superintendents but also to the electrical men of all industries is the line of threadless conduit fittings that have been recently placed upon the market. No threading of conduit is required with this fitting, the conduit being held to the fitting by an ingenious clamping arrangement by which the fitting actually bites into the conduit. The fittings are made of malleable iron thereby preventing breakage.

Here is an unusually well arranged resistor balcony.

This is a close up view of the resistor stacks for the control panels shown on the opposite page. Each stack of resistors is for the panel directly underneath it. All resistors are accessible on both sides and are mounted independently in the stack so that each resistor frame may be removed without disturbing the others. Under each stack is a large opening for ventilation and through which the resistor leads pass to the control panel. An arrangement such as shown here cannot help but receive frequent careful inspection, good maintenance and rapid repair.



Tendencies in Power Generation and Distribution

The steam turbine continues to hold first place as a prime mover in the generation of power in the steel plant. During the past year 14 units aggregating over 100,000 kw. and which were sold to steel plants, is evidence of a substantial increase in generating capacity.

On the other hand, there has been a decided increase in the amount of purchased power used in all steel districts. Most operators feel that the steel plant should generate power only to the extent of the waste heat available in the form of blast furnace gas and the like. Also, as the size and reliability of the public service companies have increased, steel mill operators have acquired more confidence in their ability to furnish continuous service.

Some interest is shown in the interconnection of steel plant and public utility generating stations for the purpose of exchanging power. This is being worked out successfully in several instances, but so far it cannot be said to be a general trend.

At the present time power factor is receiving more careful consideration in many steel plants. This has been due to a closer study of operating costs and the need for voltage improvement in power systems. Also, central stations are giving this subject more attention than in the past and are more strict in their enforcement of the bonus and penalty clauses regarding power factor. However, many of the plants visited have their power factor under con-

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trol. One plant visited has even gone so far as to automatically increase the field excitation on some of the synchronous motors driving air compressors, during periods of high maximum demand.

This plant has an average power factor of 93 per cent, which is very satisfactory indeed. All operators interviewed stated that they were using synchronous motors in every possible application. This has been one reason for the large number of synchronous motor-generator sets used, as compared to rotary converters, for obtaining direct current in steel plants.

As would be expected, the steel mills are following the developments that have become established practice for power houses in the central-station field. The main tendencies are the use of higher steam pressures, better combustion of blast furnace gas under boilers, and centralization of power houses, together with the use of larger units.

Greater interest is being shown in switching as applied to power houses and substations. This has been caused by connecting to utilities having a large power capacity and by the use of larger steel plant power houses. Hence, switches having a much greater interrupting capacity than formerly considered necessary are now required. Many plants have found it necessary to exchange low interrupting capacity circuit breakers for larger ones.

Developments and Trends in Substations

During the past year there has been an increased tendency toward the use of automatic substations. One plant in the Pittsburgh district has just purchased two equipments for controlling synchronous motor-generator sets. The Wheeling Steel Corporation at Martins Ferry, Ohio, has purchased automatic equipment for two motor-generator sets. In discussing this subject with the writer one engineer stated that he would install automatic equipment in any new substations that might be put in and had considered putting in such equipment in his present substations. Inasmuch as he had been able to get substation operators to do quite a little bench work in the substation he has been able to reduce the cost of operating the substation to such an extent that he had for the time being given up the idea of using automatic control in these stations.

The increase in the use of automatic substation control has been due primarily to the extreme reliability of operation together with the operating saving compared to manual control.

Another interesting tendency along the lines of automatic substations is the automatic pumping station. One company is installing such a station for pumping water for its blast furnace. The pumps are a very important adjunct to the blast furnace; consequently automatic operation is a step in advance. Among other things this installation will have protection for all bearings, a priming pump, and automatic starting of pump when primed. Another engineer interviewed stated that he was considering a similar installation.

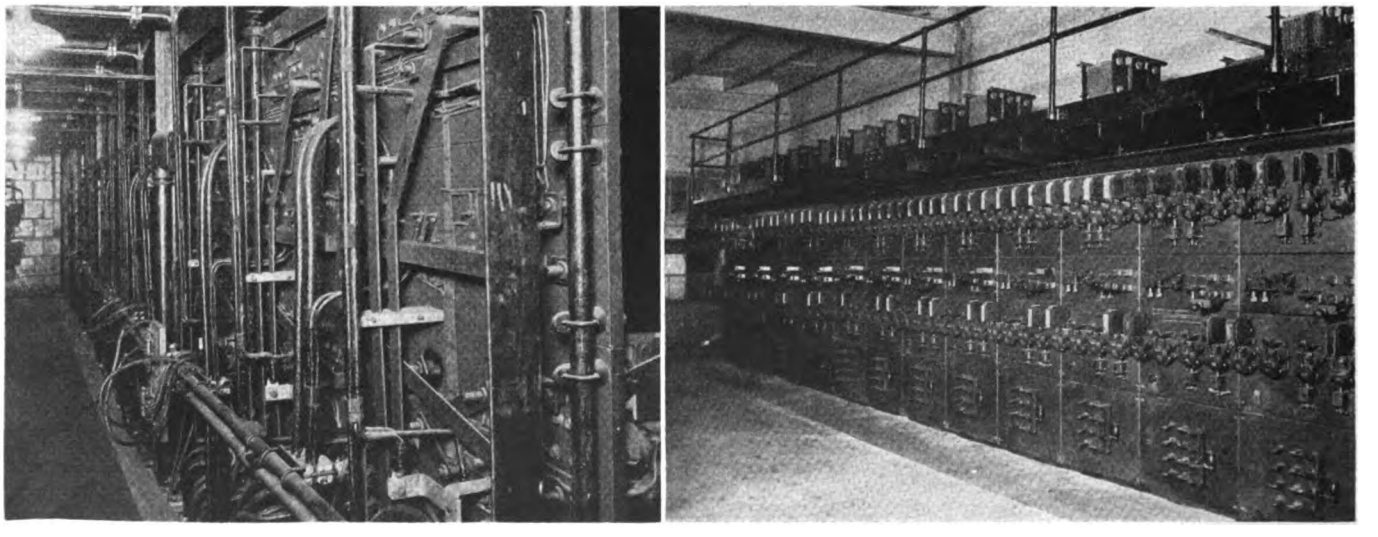
There is a very decided increase in the use of truck-type switching equipment. Many operators are swinging toward this type of switchboard because of the greatly increased safety and the ease of maintenance and repair. One objection to truck-type boards has been their increased cost over the usual type of switchboard. However, several electrical superintendents interviewed stated that when the cost of installation of both types was considered, there was not so much difference in total cost.

One large pipe manufacturer in the Chicago district is installing one of the largest truck-type boards that was ever built. Another plant in this district is putting in 12 such boards, two of which are for operation on 12,000 volts and the remainder on 2,300 volts. A notable installation of truck-type switchboards is shown in the illustration on page 411. Several motor-generator sets are controlled from these boards. A feature of this installation is that the starting and running boards for the motor-generator sets are separate and mounted on different trucks. Hence, after a motor-generator set has been started, its starting board can be removed for maintenance work or for use on some other motor-generator set in case of necessity.

(Please turn to page 457)

Another example of the trend towards better control houses for auxiliary control equipment.

These twelve panels control the auxiliary motors of the new 40-in. blooming mill at the Lackawanna plant of the Bethlehem Steel Co. The fourth panel from the left is a spare which can be switched in place of any other panel by means of the transfer switches located on the bottom sections of the regular panels. Notice that the resistors are located in a balcony over the panels. At the left is a rear view of this panel. All leads to the motors and master switches leave through conduit in the floor. The resistor leads are the leads carried vertically and held by clamps fastened to the bottom of the balcony. Ample working space is provided behind the panels.



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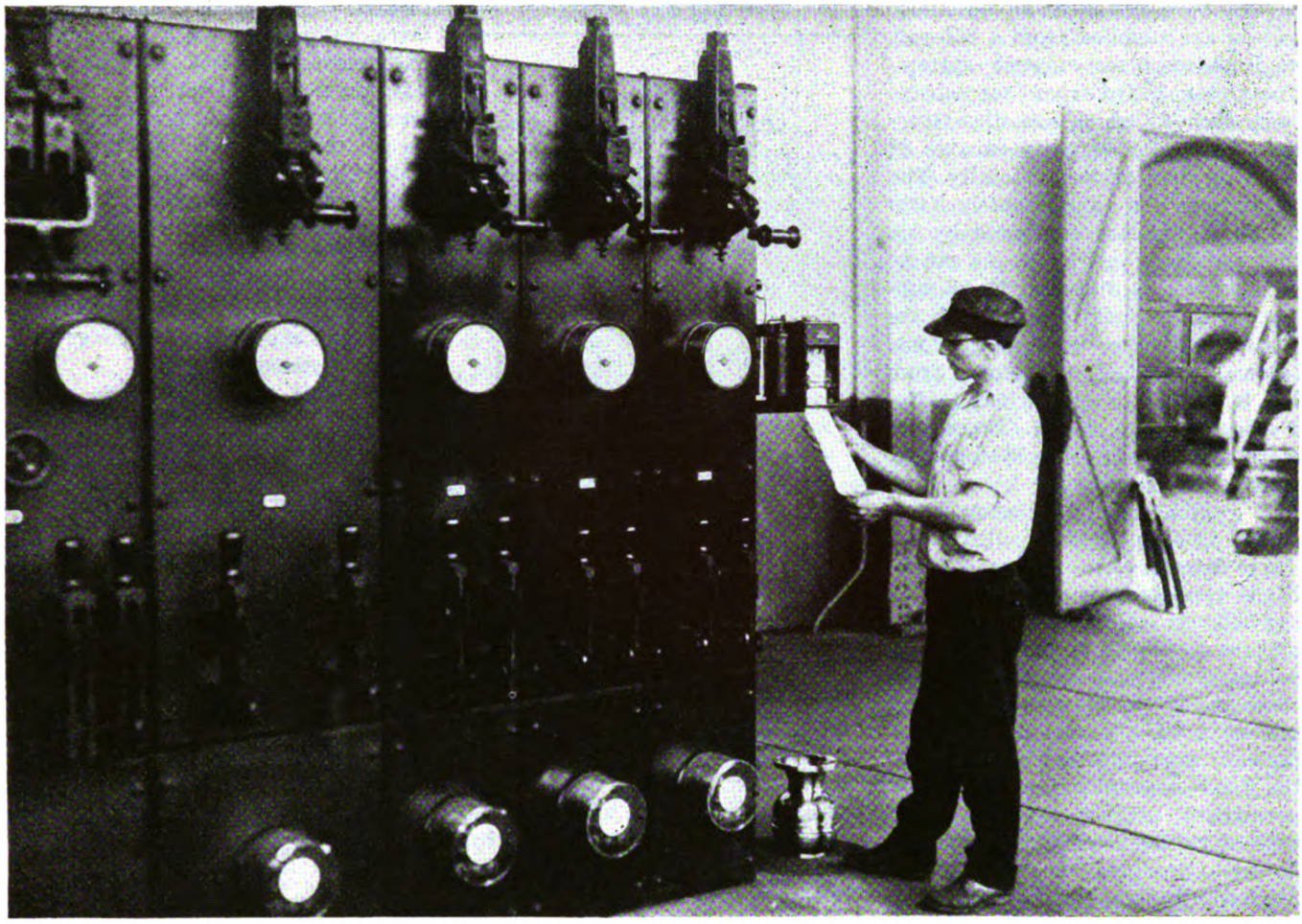


Fig. 1—Inspection of the chart from the graphic meter tells what kind of grounds are on the system and aids in locating them.

A standard graphic voltmeter is mounted on iron brackets at the end of the switchboard. The meter is connected to the bus behind the switchboard through two external resistors as is shown in Fig. 2. The resistors may be seen mounted immediately to the left of the graphic meter and on the brackets supporting the meter.

How One Progressive Industrial Plant Is

Using Graphic Meters for Detecting Grounds

On Its Direct-Current Distribution System and Power Service Equipment, Together With Details of the Installation, Typical Charts From the Graphic Meters, and the Results Obtained

By R. H. BAHNEY

Chief Electrician, The Central Steel Company, Massillon, Ohio

USING GRAPHIC meters for detecting grounds has resulted in a reduction of 26 per cent in the delays on the direct-current equipment in a steel plant having 12,285 connected horsepower of direct-current motors and has also shown a material saving in the maintenance cost on these motors and other power service equipment. In this article Mr. Bahney tells the details of the method he uses and shows how he interprets the charts from the graphic meters so as to locate the grounds.

ALL who are familiar with electrically operated plants, especially with ungrounded, direct-current systems, will realize the difficulties and loss of time frequently resulting from the failure of maintenance men to promptly locate and clear grounds that appear on the power distribution lines. The graphic meter system for detecting grounds, which is described in this article, was installed to cut down the delays resulting from these troublesome grounds. The graphic meters make a chart record of any grounds that appear on the system, thereby giving early notice of any impending ground trouble. Analysis of the chart will show the character of the ground and thus greatly aid in locating the point of failure. One of the main advantages derived is the fact that the maintenance men know that we have a continuous check on their equipment day and night. Foremen are required to report to the substation operators where the grounds were located, thereby accounting for every ground shown on the chart. Consequently the responsibility for the locating and clearing of grounds is definitely fixed.

In the plant where the graphic

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meters were installed, all auxiliary motors are supplied from a 250-volt ungrounded direct-current system. The system is fed from four substations each of which has direct-current conversion capacity capable of carrying the load in its vicinity. The substations are approximately 3,000 ft. apart and are connected by tie lines as shown in Fig. 4. As can be seen from this diagram, No. 2 substation is centrally located with respect to the other three substations. Normally the tie lines running from No. 3 and No. 5 substations to No. 2 substation are closed. No. 8 substation is tied into the system only in case of emergency.

A graphic ground detector is installed in each of these substations. These detectors are standard switchboard type graphic voltmeters having 300-volt scales. The meters have a chart speed of 2 in. per hour. The voltmeter elements are not polarized, consequently with the connection scheme used, the meter is able to indicate a ground on either side of the line. A graphic meter having a permanent magnet or D'Arsonval type of voltmeter could be used just as well, provided the scale is arranged with zero in the center instead of at one end. This latter type of meter would indicate *which side* of the line was grounded, that is, a deflection to the left would indicate a ground on one side of the line while a deflection to the right would indicate a ground on the other side of the line.

In Fig. 2 is shown the scheme of connections for the ground detector meters. The graphic meters used were designed for use with an external resistor of 1,400 ohms, when used on a 250-volt circuit. Thus it was necessary, in order to obtain a measurement of the voltage from either line to ground, to use two 1,400-ohm resistors, one connected to each line as shown in Fig. 2. This results in the two resistors being connected in series across the line with the midpoint connected to the meter and the remaining meter terminal to ground.

With this arrangement we really have a Wheatstone bridge in which the voltmeter is the galvanometer, the two 1,400-ohm resistors are two legs of the bridge, while the insulation resistance between the positive side of the line and ground is balanced against the insulation resistance between the negative side of the line and ground to form the

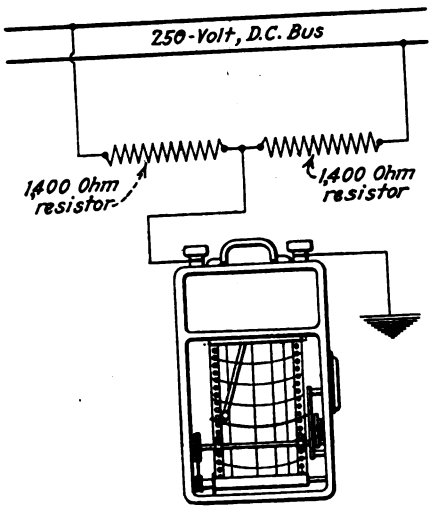
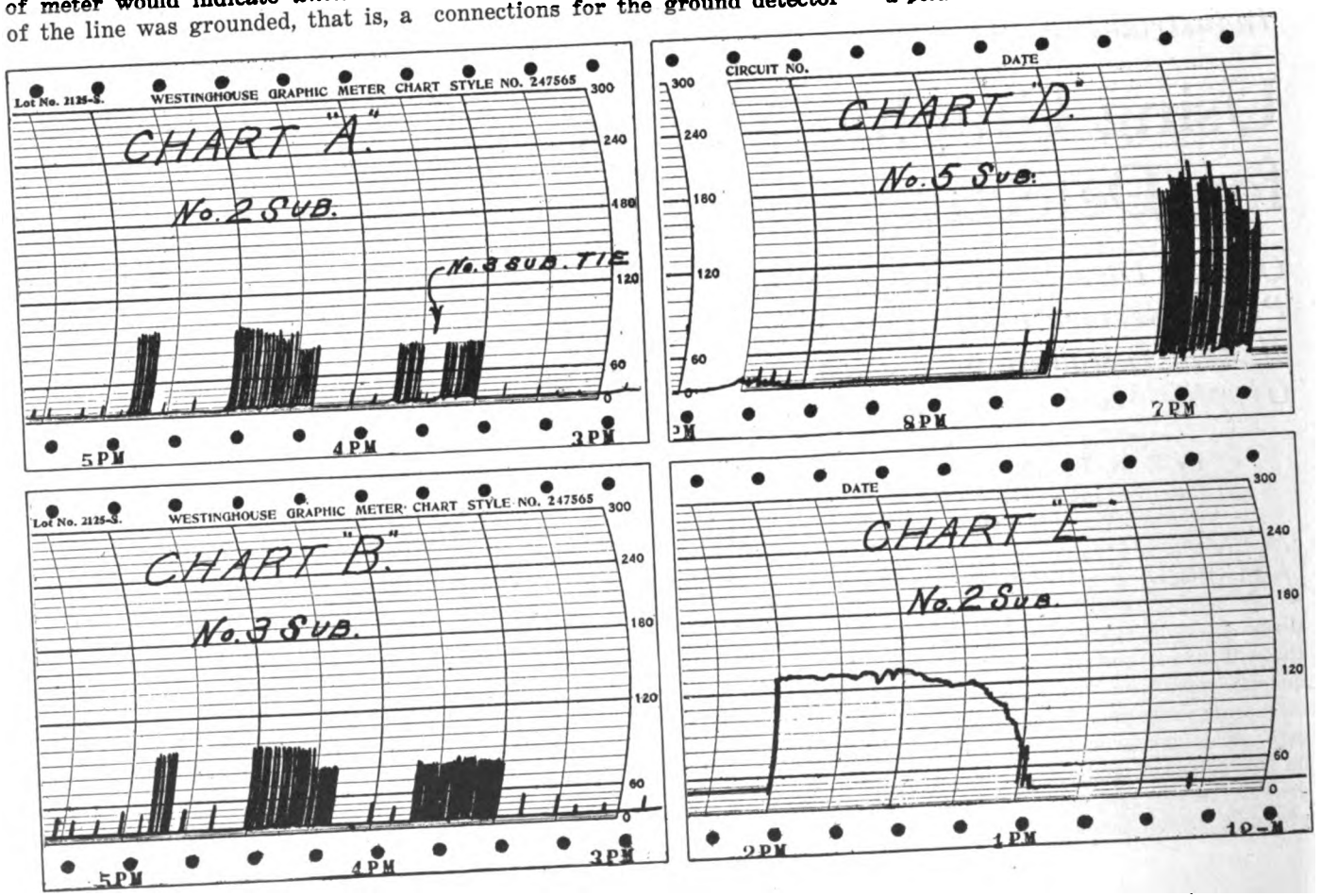


Fig. 2—Connection scheme used for the graphic ground detector.
Two 1,400-ohm resistors are connected in series across the direct-current bus in the substations. The midpoint of the resistance is connected to one terminal of the graphic voltmeter, whose other terminal is connected to ground. This results in a Wheatstone bridge with the two resistors as two legs and the insulation resistances of each side of the line as the other two legs. The graphic voltmeter takes the place of the customary galvanometer.

Fig. 3—These charts show how the character of the grounds was determined, thereby aiding in their location.
Chart *A* was taken in No. 2 substation and shows how the ground was cleared from this substation by opening the tie line breaker to No. 3 substation at 3:40 p. m. Chart *B* is the chart that was taken in No. 3 substation at the same time. The ground did not clear at 3:40 p. m. thereby indicating that it was on one of the feeders from this substation. Charts *D* and *E* show the difference between a reversing and a permanent ground.



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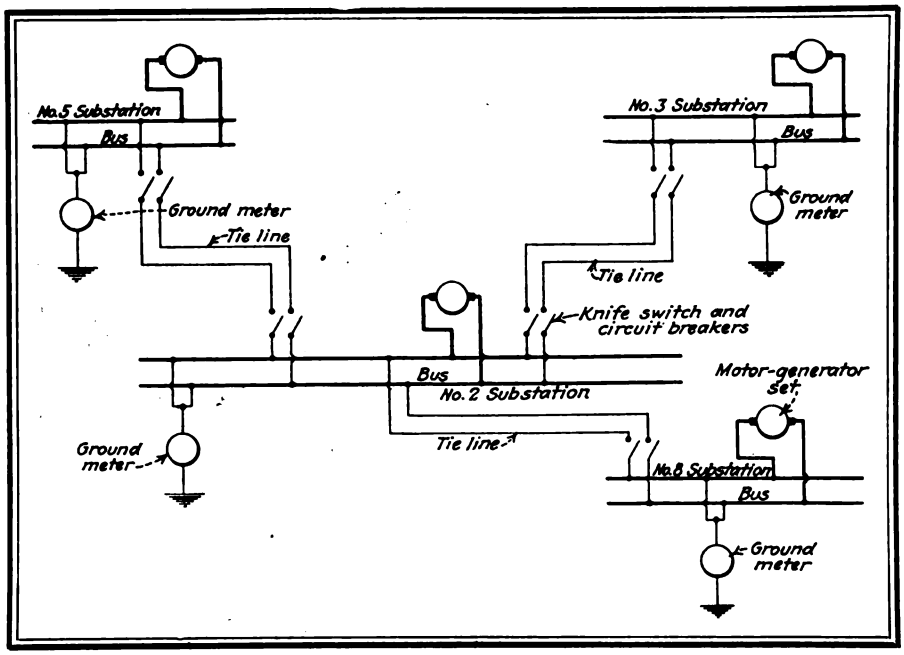


Fig. 4—One graphic ground detector is placed in each substation. As can be seen, there are four substations in this plant, which are tied together by tie lines. When indication of a ground is shown on the chart of one of the graphic ground detectors, the tie lines are opened so as to isolate the substation in which the meter is located. If the indication continues on the chart, the ground is on the section of the system which this substation serves. Interpretation of the character of the curve given by the graphic meter further aids in locating the ground.

other two legs of the bridge. As long as the insulation resistances between the two sides of the line and ground are approximately equal the voltmeter will give a zero indication. However as soon as an insulation failure or partial ground occurs the balance will be upset and the graphic voltmeter will give a deflection. Our experience has been that the meter will accurately show a ground as low as 20 or 30 volts, which in reality is a negligible ground.

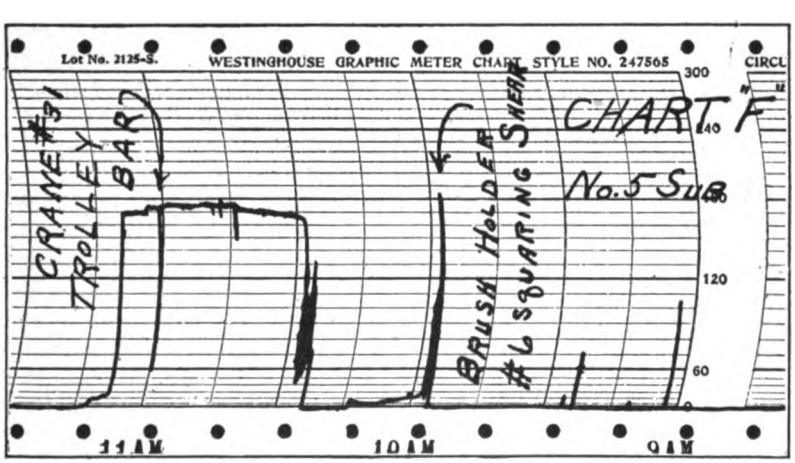
In case a graphic voltmeter not requiring an external resistor is to be used, two lamps may be connected in series across the line and the midpoint between the two lamps connected to the meter just as was done with the resistors.

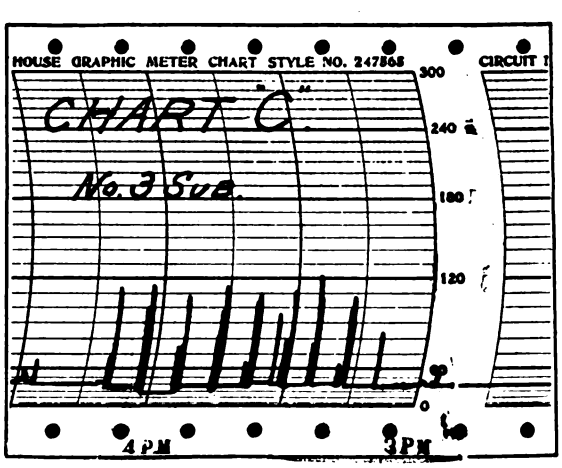
The ground meters are located on the front of one of the panels in each substation as shown in Fig. 1, where they are clearly visible to foremen and operators in passing. When an operator notices a deflection on the chart of his ground meter, he opens up the tie-line circuit breaker so as to isolate his section of the system from the rest of the distribution system. If the deflection on the meter continues, he knows that the ground is on one of the feeders going out from his substation or on the motors supplied by these feeders. If the meter goes to zero when the tie-line circuit breaker is opened, he then knows that the ground is not in his part of the system. Assume that the operator in No. 2 substation observes a deflection on his meter. He immediately opens the tie circuits to No. 3 and No. 5 substations. If the meter returns to zero, this at once localizes the ground to the sections of the distribution system in the vicinity of either No. 3 or No. 5 substations. He then closes the tie circuit to No. 3 substation and notes the effect on the ground meter. If a deflection is obtained, this shows that the ground is on the distribution from No. 3 substation. No. 2 substation operator then calls the operator in No. 3 substation and reports to him the results of his test which he can verify by the record on No. 3 substation graphic meter at the time the tie circuit was opened. The operator, in the substation at fault, then advises the foreman in that department of the ground on his equipment.

A study of the interval and duration of the lines on the graphic charts is of great help to the foreman in definitely locating the machine at fault. Chart *A* of Fig. 3 is taken from the graphic meter in No. 2 substation. At 3:30 p.m. a ground appeared. It was unnoticed for the first ten minutes after its appearance. At 3:40 p.m. the operator saw the record on the chart and started opening the tie line breakers. As soon as the tie-line breaker to No. 3 substation was opened the graphic indicated zero voltage, thereby showing that the ground was in that part of the system fed from No. 3 substation.

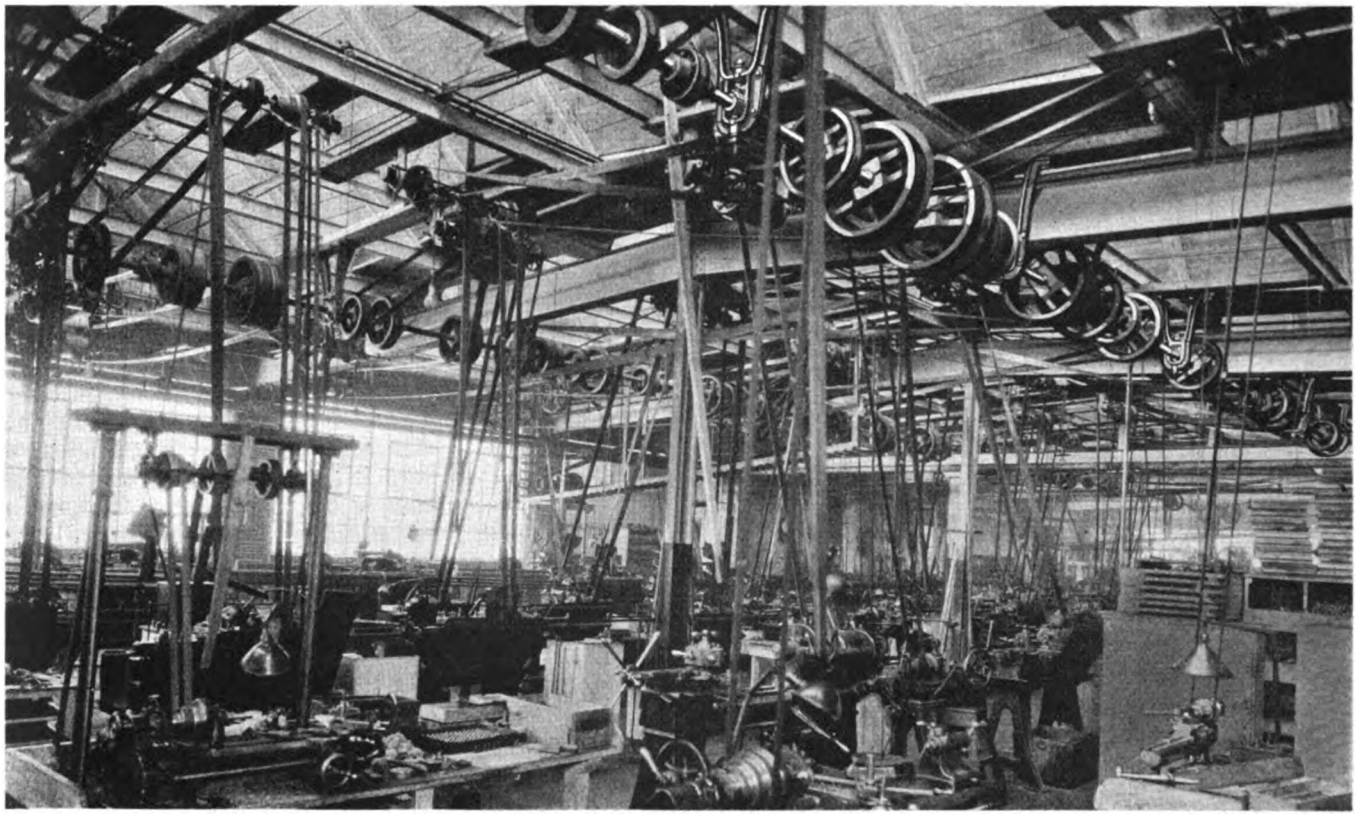
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Fig. 5—The chart gives a record of the time at which the ground appears and the time elapsing before it is cleared. This gives an incentive to clear the ground as quickly as possible because the record then shows that the maintenance man is on the job. In chart *F* a ground appeared, which was quickly found to be on the brush holder of a shear motor. Twenty-five minutes later another ground appeared which was not located for 40 min. It was found on a trolley collector rail of a crane. As soon as a ground has been cleared notations are made on the chart as shown to tell the location of the ground.





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Here two lineshafts which transmit power to a miscellaneous group of machines are belted together and driven by one motor.

Some of the Points To Consider When

Planning a Lineshaft Installation

With Factors Which Determine Size of Shaft Required and Affect Method of Grouping Machines on Shafts That Transmit Power to Them

By FRANK E. GOODING
Associate Editor, Industrial Engineer

DIAMETER of a lineshaft for a group drive in industrial plants is altogether too often determined by a combination of guess and a few rules of thumb. Frequently the diameter is determined by comparison with another shaft which it is assumed "has about the same load."

This size so determined is usually checked against a table or chart supplied by a manufacturer of shafting and, if within that rating, is used. These tables are calculated for shafts operating under ordinary conditions and unless some machine or drive is larger than is ordinarily found in the average group drive, using such a size of shaft, the installation will probably operate satisfactorily.

Several points which affect the determination of the size of the lineshaft would, if understood better, be more appreciated and considered in both the estimation of the size and in the layout or arrangement of the installation. These points must necessarily be general in that lineshaft installations are seldom alike.

Practically all industrial plants are different in the layout and arrangement of the machines and in the size and shape of the buildings. Economical and efficient production determines the grouping and arrangement of the machines. This is much more important in plants working on a definite product or group of products because the routing of the material and semi-finished parts must then follow as nearly as possible a straight line. The machines must be placed so as to permit this if possible. Whether such positioning of the machines requires one or several lineshafts is of secondary importance, compared to the effectiveness of the arrangement.

The value of effective arrangement of machines is so great that in several shops, which manufacture various products in large quantities, the machines may be lined up in one arrangement for a month or more to manufacture a certain product and then be rearranged to manufacture something different. One company

WHEN LAYING out lineshaft installations, operating men altogether too frequently neglect to take into account some of the factors which may cause loads of unsuspected magnitude to be put on a lineshaft. This article discusses these factors from the standpoint of how their effects may be calculated, and minimized. Articles which will appear in later issues will discuss some of the points to be considered in the installation of lineshafts.

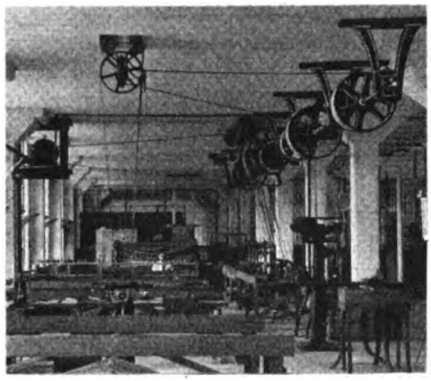
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even moves lineshafts and countershafts as may be necessary to improve the layout of the machinery on jobs which last only a month or two. Here the whole plant will work on one job until it is finished and then take up the next order, rearranging the machines and drives as necessary.

Ordinarily shops which do jobbing or a variety of work such as tool rooms, manufacturing plants that do jobbing on contract, and factories which turn out a variety of products, group machines of a type together. These groups of one type of machines generally make easier lineshaft layouts than when a variety of machines are arranged together, as is frequently the case.

Advantages of Small Groups Over One Large Group

A number of advantages result from making several small groups of lineshaft drives instead of one large group, even though it is possible to use a single group and one lineshaft. In the first place, lineshafts of smaller diameter may be used, which will also take smaller hangers and bearings. This will decrease the cost of the shaft, bearings, and hangers. Shafting is sold by weight and a 3 7/16-in. shaft weighs twice as much per foot as a 2 7/16-in. shaft and three times as much as a 1 15/16-inch shaft. The cost of bearings and hangers increases with increase in shaft size in about the same proportion.



The lineshaft speed is made to fit all machines but one.

When determining the speed at which the lineshaft is to operate, an average speed, suitable for the different machines, is chosen. Usually, however, a few machines operate at speeds considerably above or below the average. In such cases it is generally best to ignore them in computations, so as to obtain the most suitable speed for the average machines. The few exceptional machines can then be driven through countershafts, as is the small grinder in this illustration, to better advantage than by using a speed poorly adapted to the majority of machines. Many lineshaft speeds are held down to accommodate the low operating speed of a power-driven hacksaw. It would be much more economical and effective to operate the lineshaft at a higher speed and install a countershaft, similar to the one used here on the grinder, to step down the speed for the hacksaw.

Under average conditions a 2 7/16 in. shaft will carry about twice the load of a 1 15/16-in. shaft. The 3 7/16-in. shaft will carry about five times as much as a 1 15/16-in. shaft and between two and three times as much as a 2 7/16-in. shaft. Thus an installation which requires a 3 7/16-in. shaft could be split up into four groups each of which would take a 1 15/16-in. shaft. If the load on the single shaft were 40 hp. each of the smaller shafts could be operated at about 10 hp. The four smaller shafts, hangers and their bearings would cost about a third more than for a single big shaft of the same length. The cost of erecting the four smaller shafts, however, would most likely be less than for the one large one because they could be handled more easily.

Four individual motors would cost a little over twice as much as a single large motor of the same rating. A single large lineshaft would probably require one or more auxiliary lineshafts, which would add to the cost. The four smaller groups would probably not require any additional auxiliary shafting, which would be an advantage.

Although the four groups would probably cost more for the complete lineshafts and motors than the single shaft layout there are other advantages in the smaller groups which would largely offset this. For instance, in case only a few machines were to be operated overtime only one or perhaps two groups might need to be operated. With a single

Table for Determining Horsepower of Shafting Under Different Conditions

Diameter of Shaft	For Head Shafts, Heavy Strains, shafts with gears, etc. H. P. = $\frac{D^3R}{125}$								For Line Shafts, with bearings every 8 ft. H. P. = $\frac{D^3R}{75}$								For simple transmission of power with no bending strains. H. P. = $\frac{D^3R}{50}$							
	Revolutions per minute								Revolutions per minute								Revolutions per minute							
	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500
1 3/16	0.6	1.3	1.8	2.6	3.3	4	5	6	1	2	3	4	6	7	9	11	2	3	5	7	8	10	13	17
1 7/16	1.2	2.3	4	5	6	7	9	12	2	4	6	8	10	12	16	20	3	6	9	12	15	18	24	30
1 11/16	2	4	6	8	10	11	15	19	3	6	10	13	16	19	26	32	5	10	14	19	24	29	38	48
1 15/16	3	6	9	12	15	17	23	29	5	10	15	19	24	29	39	48	7	15	22	29	36	44	58	73
2 3/16	4	8	13	17	21	25	33	42	7	14	21	28	35	42	56	70	10	21	31	42	52	63	84	105
2 7/16	6	12	17	23	29	34	46	58	10	19	29	39	48	58	77	97	14	29	43	58	72	87	116	145
2 11/16	8	15	23	31	39	46	62	78	13	26	39	52	65	78	104	129	19	39	58	78	97	117	155	194
2 15/16	10	20	30	40	50	61	81	100	17	34	51	68	85	101	135	169	25	51	76	101	127	152	203	254
3 7/16	16	32	49	65	81	97	130	162	27	54	81	108	135	163	217	271	41	81	122	163	203	244	325	406
3 15/16	24	49	73	98	122	146	195	244	41	81	122	163	204	244	326	407	61	122	183	244	305	366	488	610
4 7/16	35	70	105	140	175	210	280	....	58	117	175	233	291	350	466	....	87	175	262	350	437	524	699	....
4 15/16	48	96	144	192	240	290	385	....	80	161	241	321	401	481	642	....	120	241	361	482	602	723	963	....
5 7/16	66	133	200	265	332	400	....	....	111	222	333	444	555	666	....	....	166	333	499	666	832	998	....	....
6	86	173	260	345	432	520	....	....	144	288	432	576	720	....	....	....	216	432	648	864	1080	1296	....	....
6 1/2	110	220	330	440	550	....	....	....	183	366	549	732	915	....	....	....	275	549	824	1099	1373	....	....	....
7	137	275	412	550	686	....	....	....	229	457	686	915	1143	....	....	....	343	686	1029	1372	1715	....	....	....
7 1/2	170	337	506	675	....	....	....	....	281	563	844	1125	....	....	....	....	422	844	1266	1688	....	....	....	....
8	205	410	614	820	....	....	....	....	341	683	1024	1365	....	....	....	....	512	1024	1536	2048	....	....	....	....

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shaft for all machines the whole line is operated even if only one machine is to be used. Also, with the several smaller groups it is feasible to keep a spare motor which could replace quickly any one of the motor drives which might fail. Any such failure would interrupt the operations of only one group and so only part of the shop would be down in case a motor failed and no spare was available. When a number of machines are divided into several groups it is usually possible to get a better arrangement of the equipment and often a more effective utilization of the space. It is far better and more economical to put an installation in as it ought to be, even though the first cost is higher, than to make the best of a poorly planned layout which must always be operated uneconomically or changed later at an added expense.

The laying out of machinery in the most economical arrangement is a special task which space does not permit of extensive treatment here. Probably the best method to use is to make a drawing of the floor plan and then, on the same scale, draw and cut out templets of each machine to be installed. The problem then is a cut-and-try arrangement of these templets until they are placed in the best position for routing of work, aisle space, lighting, convenience and power drive. The result is usually a compromise on some of these points.

In determining the diameter of lineshaft for any particular installation the fact that every shaft is under a bending and twisting stress cannot be given too much importance. The bending stress is the more important of these and also is the more generally neglected. Although the size of a lineshaft is usually determined from data, such as given in the table on page 419, it is well to check the larger and heavier drives taken off the lineshaft to find their effect upon the shaft.

The bending stress is due to the pull of the belt, the weight of the pulley and its distance from the hangers. On any belt drive the effective belt pull is the difference in tension between the tight and the loose sides of the belt. For example, if this difference in tension is 100 lb. and the belt speed is 3,300 ft. per min., the belt is transmitting 10 hp. Under general conditions the tension of the belt on the tight side is about twice that on the slack side. Thus, in the example given above, the pull on the tight side of the belt would be 200 lb. and on the slack side 100 lb. which, with the addition of 100 lb., for the weight of the pulley, would make a total bending load of 400 lb. due to this single drive. Assume, for convenience, that this pulley is placed midway between the hangers, which are ordinarily spaced 8 ft. apart. The bending load is therefore [400 (lb.) ÷ 2] × [96 (in.) ÷ 2] = 9,600 inch pounds.

Increasing the distance between the hangers, however, increases the bending moment proportionately even though the load is not changed. Thus, if the same load were placed midway between hangers 12 ft. apart the bending moment would be 14,800 in.-lb.

The corresponding twisting moment of this drive, assuming a 36-in.

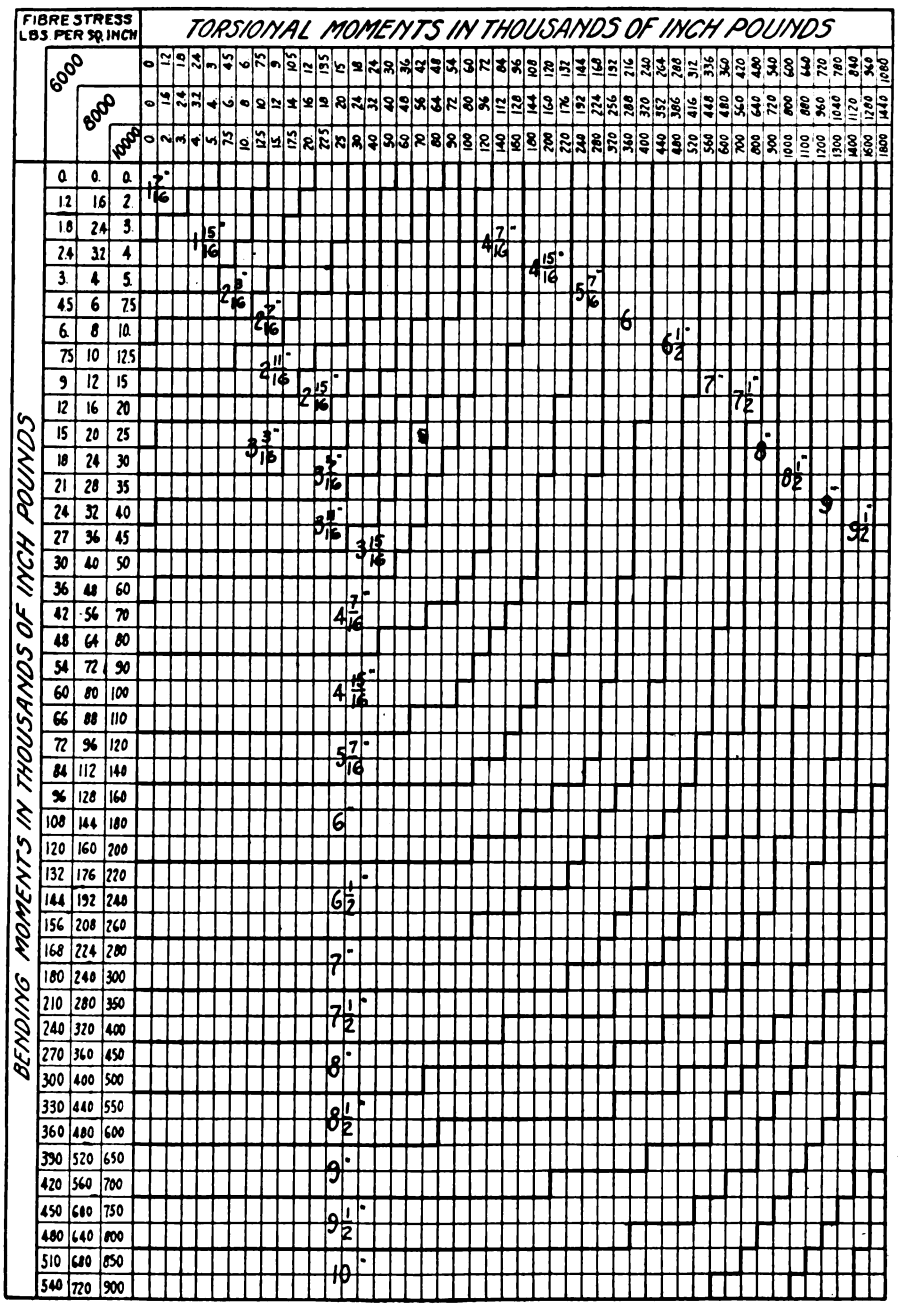
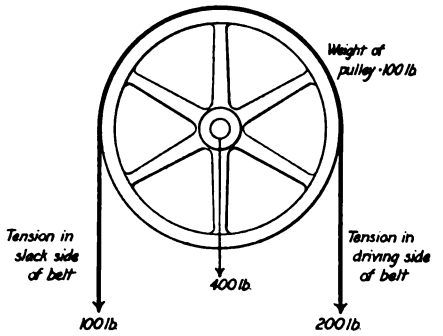


Chart of combined torsional and bending moments for determining proper shaft sizes.

After the bending and torsional moments have been computed, as explained in the text, the shaft size as determined by the table on page 419 is checked with this chart to see that the stresses do not exceed the permissible loads on that shaft size. The first step in this is to determine the permissible fiber stress in pounds per square inch, which is given in the upper left-hand corner of the chart. For light service the higher figure is used; for heavy service it is desirable to use the low figure. The figures at the top of the chart show the permissible torsional moments in thousands of inch-pounds for these fiber stresses; the column at the left shows the permissible bending moments in thousands of inch-pounds. In using the chart extend a vertical line down from the torsion load to the intersection of a horizontal line from the bending load. The intersection shows the size of shaft to use.

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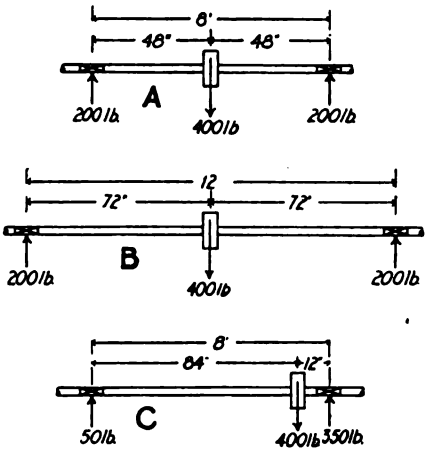
This shows the direction and magnitude of the force which causes bending of a lineshaft.

This bending force equals the tension in the tight side plus the tension in the slack side plus the weight of the pulley. The effect of this force on the lineshaft depends upon the distance of the pulley from the hanger, as is shown in the three sketches, *A*, *B* and *C* at the right. In the above sketch the ratio of tensions between the slack and tight sides of the pulley is one to two. With high-speed belts this ratio is sometimes increased to one to three.

Power Required for Group of Machine Tools

MACHINE	HORSEPOWER
1 band saw	3
1 18-in. lathe	4
2 10-in. lathes	4
1 shaper	3
1 power forge	1
1 power hacksaw	½
1 large drill press	10
3 small pattern lathes	3
2 small tapping machines	2
1 small drill press	2
1 milling machine	3
4 small tool grinders	12
1 small bench lathe	1
Total horsepower	48½

NOTE: On this particular group drive a 10-hp. motor belted to the lineshaft was used. The motor horsepower in this case is 21 per cent of the total rated horsepower of each machine. In some cases where it is likely that many of the machines will be in operation all of the time the driving motor must be about 50 per cent of the total rated horsepower of the individual machines.



Three typical examples of the effect of the application of the load on the bending moment.

The effect of the bending moment upon the shaft is altogether too often neglected in determining sizes of shafts. These three sketches show typical examples of pulley locations and the effect of location upon the load. In *A* the pulley is placed midway between the two hangers, which gives it the highest bending moment possible on this type of installation. The bending moment is increased 50 per cent when the shaft hangers are placed 12 ft. apart, as in *B*. The resultant effect on shaft sizes is discussed in the text. Conversely, in *C* the bending moment is considerably decreased by placing the pulley close to the hanger. This is not only very desirable from the effect on the size of shaft required and its first cost, but also makes for more effective operation.

pulley, would be 100 (lb. effective pull) × (36÷2) = 1,800 in.-lb.

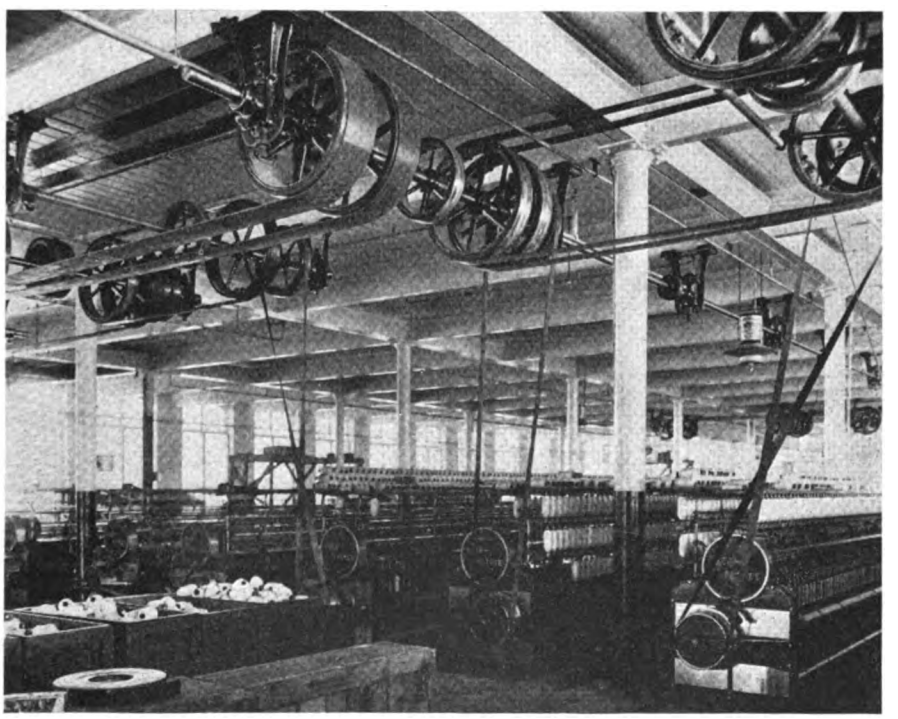
Reference to the chart of "Combined Torsional and Bending Moments" on page 420 shows how these loads affect the shaft size. The detailed explanation of the use of this chart is given in the caption accompanying it and will not be repeated here. Assume that the desirable fiber stress should not exceed 8,000 lb. per sq. in. The results are that a 1 7/16-in shaft would take care of the torsion load if no bending load were present. However, the bending moment of 9,600 in.-lb., with hangers 8 ft. apart, would require a 2 7/16-in. shaft and the 14,800-in.-lb. bending moment resulting if the hangers are 12 ft. apart would require a 2⅞-in. shaft.

If, however, this pulley were moved to a distance of 1 ft. away from the hanger on the 8-ft. spacing the bending moment would be 350×12=4,200 in.-lb. which is not too heavy a stress for a 1⅞-in. shaft. The twisting or torsion load would not be affected by the position of the pulley relative to the hanger.

From this it is easily seen that the most attention must be given to the bending load and the effect of the position of this load with respect to the hangers. It is not the load alone but how it is applied that finally determines the size of a lineshaft, even though the rating is satisfactory as shown by a table similar to the one on page 419.

These facts bring out some of the most important points to consider. While 8-ft. spacing between hangers is good industrial practice it, should, nevertheless, not be such a fixed and set rule that the spacing can not be decreased or an additional hanger installed, where necessary, to place a hanger near a heavy bending load. If the shaft is already installed and a relatively heavy load for that shaft is moved so as to come midway between two hangers it is well to install another one nearer the load.

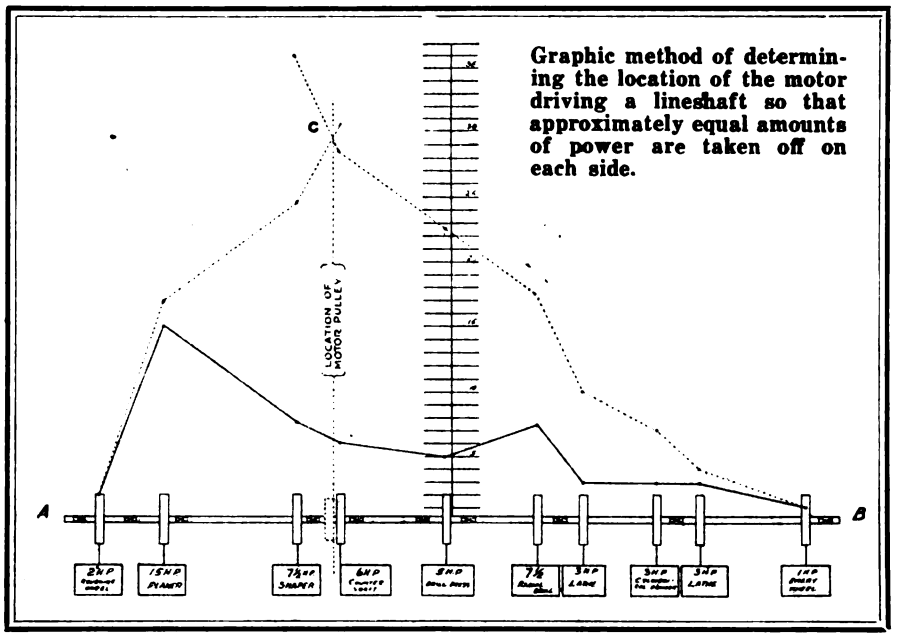
The arrangement of industrial machines is varied so frequently that it



A group of main and auxiliary lineshafts in a textile mill.

Where long machines, such as these, are driven from lineshafts it is often necessary to group several pulleys between a pair of hangers. In such cases it is always advisable to place them as near the hanger as possible. How the bending moment on the lineshaft is affected by the distance the load is applied from the hanger is discussed in the text and in the captions accompanying the drawings at the top of the page.

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Graphic method of determining the location of the motor driving a lineshaft so that approximately equal amounts of power are taken off on each side.

is seldom advisable to lay out lineshafts with the hangers spaced over 8 ft., even though at that time certain sections of the shaft do not drive any machines. In almost any shop additional machines are installed from time to time, which fact must be kept in mind when designing any lineshaft installation.

The permissible deflection of a lineshaft is 0.01 in. to the foot. If the hangers are spaced too far apart and a heavy load placed midway this deflection is often exceeded and is one of the most common reasons for pulley spokes breaking near the rim. This is due to the continual "weaving" of the face of the pulley as it is pulled straight by the belt while the pulley itself is tipped by the bending of the shaft. Breakage of pulleys where the spokes join the rim indicates that the lineshaft is too small, but can generally be remedied by adding a hanger close to the pulley.

Next to the loading of a lineshaft the speed at which it is to operate is of most importance. The tendency of the present-day installations is toward higher speeds. Much of this is due to the increasing use of ball, roller, and tapered-roller hanger bearings. Also, there is an advantage in using high-speed motors as these are cheaper and usually more efficient. If the lineshaft is speeded up, a smaller ratio of reduction is required between shaft and motor.

Because the power transmitted by any lineshaft is determined by the speed, any increase in the speed of the shaft will permit not only the use of smaller pulleys to obtain the same or higher belt speeds but also the use of a smaller size of lineshaft. Lower belt tension and generally narrower belts and pulleys may be used with higher speed operation, which lowers the first cost.

One power transmission engineer endeavors to make machine shop lineshaft installations operate at about 250 to 300 r.p.m. Former practice has been to operate shafts in this industry at 125 to 175 r.p.m. Because manufacturers of metal working machinery have almost standardized on this lower speed of lineshafts, many of the machines are provided with pulleys which would give a good reduction ratio when operating at the lower speeds. The tendency today is toward high-speed operation of these machines and so in many cases only small changes are necessary in the pulleys and the machines in order that they may be connected to a higher-speed lineshaft. This engineer stated that in several installations the only machine which he was not able to connect to a high-speed lineshaft was a power hacksaw. He felt, however, that the advantages of operating all of the other machines at an economical speed overcame the disadvantages in connecting the hacksaw, which required a contershaft reduction. The modern practice with woodworking installations is to drive the lineshaft at 400 to 600 r.p.m. Practically all woodworking machinery operates at a high speed.

In determining the speed of a shaft, it is necessary to take what might be termed a good average operating speed for the entire group of machinery. The few exceptions which cannot be made to fit in with this speed can be taken care of to better advantage individually than by permitting the remainder of the machinery to run uneconomically so that special arrangements will not be necessary for the few exceptional machines.

An economical installation, taking into account the cost of pulleys and belts, operates at an approximate belt speed of 2,000 ft. per min., according to some curves and estimates made by R. C. Moore, Chief Engineer, Chas. A. Schieren Co. This belt-speed is somewhat low for

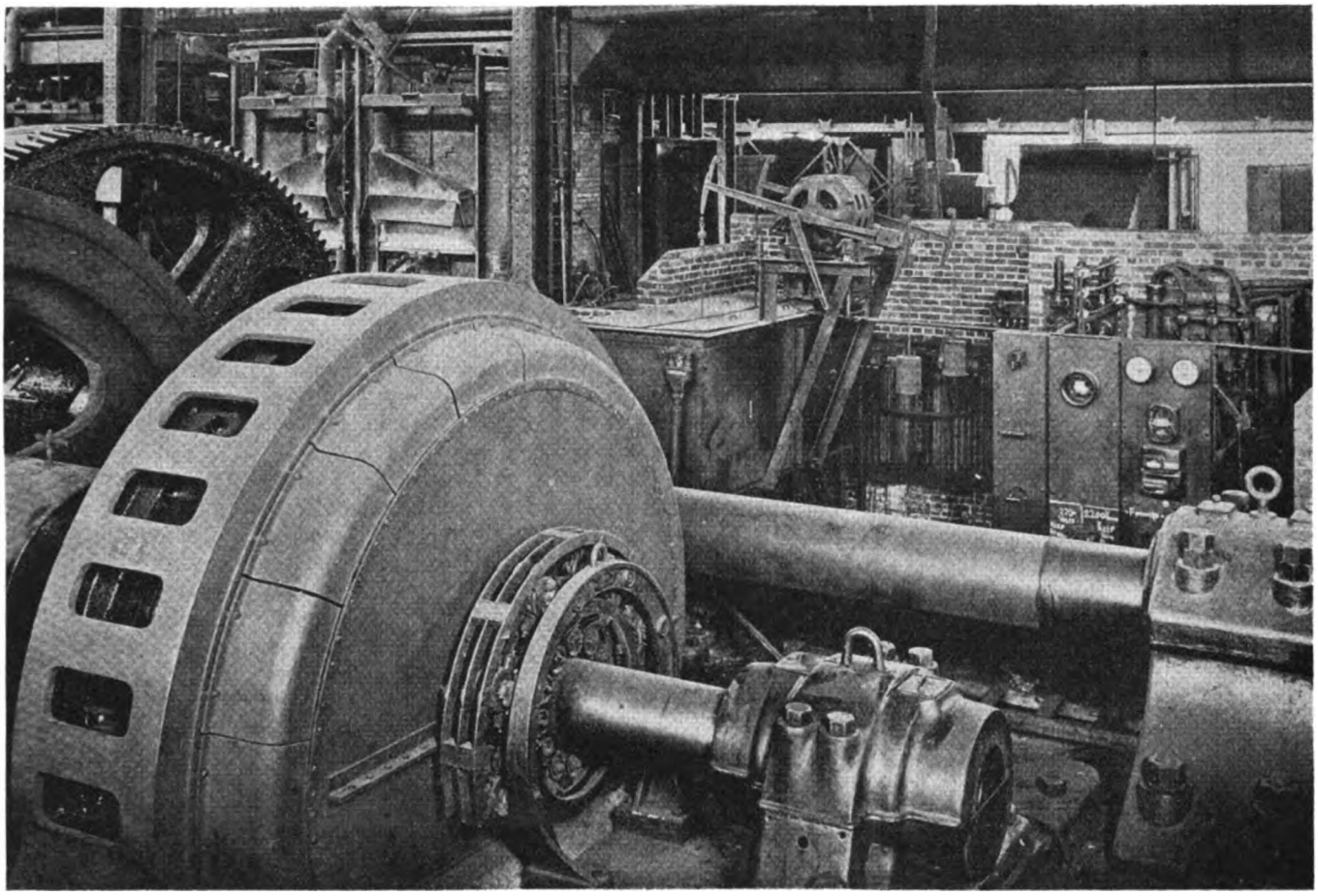
(*Please turn to page 460*)



A typical arrangement of a group drive.

In the arrangement of this group of machines particular attention was given to placing those which require the best lighting near the window. Note the criss-cross arrangement of lineshafts and countershafts.

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Good maintenance requires that the insulation be kept clean. When the motor is not located in a separate motor room, keeping the motor clean is sometimes quite a problem. In this hot sheet mill, enclosing covers were placed on the motor and air from an air washer is forced through a ventilating duct to the motor. The air washer and blower are shown on page 456.

Important Factors Regarding the

Maintenance of Large Motors in Steel Mills

Including Methods of Protecting Equipment From Dust, Dirt, and Sweating Together With Tests That Should Be Periodically Made on the Machines

By O. NEEDHAM

Steel Mill Section, General Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

AN ANALYSIS of a sample of dust taken from the bedplate of a rolling mill motor showed that 81 per cent of the sample was composed of good conducting material, which would tend to introduce creepage currents that would break down the insulation of the motor. It is for this reason that greater precautions must be taken to protect electrical equipment in steel mills than in many other industries. In this article Mr. Needham describes some of the methods that may be used to prevent the accumulation of dust in the motor and sums up details of the maintenance required on large, steel mill motors.

THE need of insuring proper maintenance — an important one with respect to any kind of machinery—is especially important with regard to electric equipment for large motors in steel mills.

All electric motors, reduced to their simplest form consist of copper for conducting the currents, iron for forming the magnetic path, and insulation for confining the electric current to the copper conductors. In addition to the above there must be mechanical parts for properly holding the working material together and for transmitting the power mechanically to the driven mechanism. This latter refers particularly to the spider, shaft and bearings.

Since all rotating electric machines, except squirrel cage induction motors, must receive or deliver some of their electric current through sliding contacts, which are commutators on direct-current machines and slip rings on induction and synchronous motors, these sliding contacts must also be regarded as a vital part of the machine.

A consideration of proper maintenance must, therefore, give attention to each of the divisions mentioned above.

Very little can happen to the copper and iron parts of a motor except from vibration, or excessive peak loads which might distort or crystallize the copper conductors. A number of things can affect the bearings,

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such as vibration, dirt, improper lubrication and excessive pressures.

Commutators are affected by moisture and oil as well as vibration and dirt. Sparking may result from the above and also from roughness, high mica, improper brushes, and improper brush position. Numerous articles have been written covering causes and remedies for sparking and this will be passed over here with the comment that commutators must be kept free from moisture, oil, and dirt, and they must be stoned or ground when they become rough. The commutators should be checked occasionally to make sure that the holding bolts have not loosened.

Slip rings should be kept clean, true, and smooth and operated with proper and well-fitting brushes.

Insulation is the most vital part of the motor and unfortunately the most delicate. Insulation is affected by heat, dirt, oil and moisture, vibration, and abnormal voltages.

In reviewing the foregoing the one thing that affects the entire machine is mechanical vibration. This may cause crystallization and breakage of copper conductors, loosening of iron, damage to commutators, and pounding out of bearings. The vibration may be caused by improper alignment, loose foundation bolts, unbalanced rotor, unbalanced coupling, or may be transmitted to the motor from the mill equipment. It may also be caused by unbalanced electrical circuits. Careful attention must be given to all of these points at the time the installation is made and during subsequent periodic inspections.

Excessive bearing pressures may result from misalignment or from bent shafts. These points should receive attention from the inspector in his rounds. Bearings are also affected by vibrations which may develop a pumping action causing loss of lubrication. This also may damage the babbitt by pounding. Dirt getting into bearings is very disastrous as it will grind out the babbitt and cause heating. It also pollutes the oil rendering it unfit for use. The oil must be kept clean and changed or filtered as often as necessary. Under favorable conditions and ordinary care, once a year is ample. However, the oil should be inspected every month or at any time that there is reason to suspect that dirt has found its way into the bearings and must be changed or filtered upon any evidence of dirt or grit. The extremes of temperature at any locality may have considerable to do with the selection of the proper grade of oil to be used but a little study and observation will enable an operator to determine the best grade of oil for his conditions.

Causes of Deterioration of Insulation

We next come to the important question of insulation. In accordance with the standardization rules of the American Institute of Electrical Engineers, steel mill motors are given an insulation test at the factory of twice normal voltage plus 1000 volts, insuring an ample factor of safety against insulation breakdown, but this wide margin of safety is naturally reduced after the machines are in service. The rate of deterioration depends on several causes, the principal among which are, excessive overloads, abnormal voltage, mechanical vibration, and accumulation of dirt and moisture. The moisture may be the result of sweating or of other causes. Let us consider each of these causes in turn.

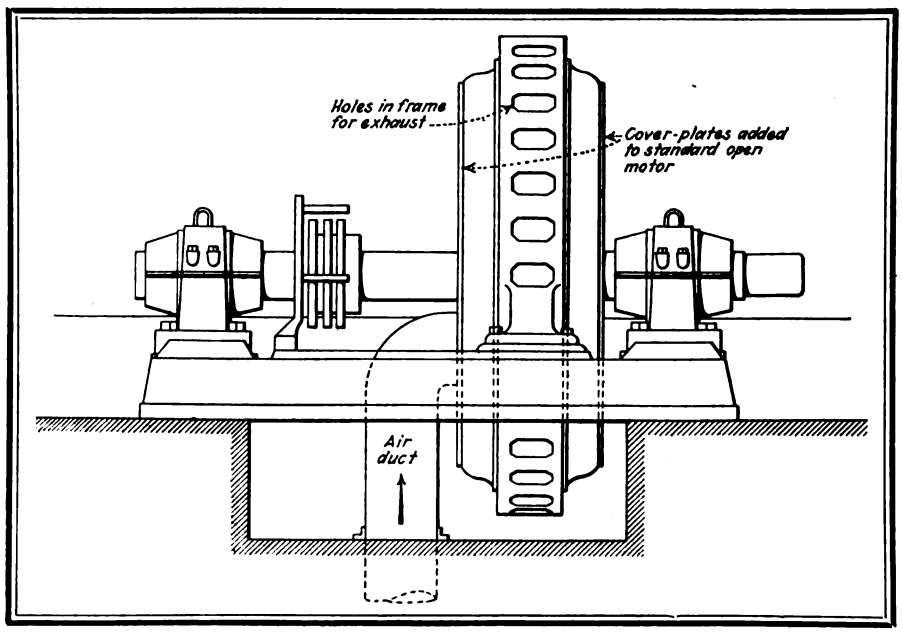
Overloads—Motors must be protected against injurious overloads by proper control apparatus.

Abnormal Voltages — Abnormal voltages may be occasioned by partial grounds, lightning, etc., and the insulation should be protected from break-downs due to this cause by suitable lightning arresters, reactors, and other standard devices.

Vibration—As stated before in this article mechanical vibration is caused either by improper alignment, loose foundation bolts, unbalanced couplings, or is transmitted to the motor from the mill equipment. Whenever possible the motor should be protected from vibration from the mill by the use of well-balanced flexible couplings.

How a standard open type motor may be arranged for forced ventilation.

Cover plates are added to the sides of the motor so as to tightly enclose it. Air is forced through a duct brought in at the bottom and at one side of the motor, goes through the motor, and exhausts into the room through the holes in the periphery of the frame. This method was used for the hot sheet mill motor shown on page 423.



Dust Is the Most Common Source of Trouble in Windings

A very common source of trouble is the collection of dirt and dust in the windings. An analysis was made of a sample of dust taken from the bedplate of a rolling mill motor and the composition was found to be as given in the accompanying table. The carbon, iron oxide, and water compose 81 per cent of the sample and each of these components form good conducting material, which would tend to introduce creepage currents that would break down the insulation of the motor. It is for this reason that greater precaution must be taken in steel mills to protect electrical apparatus than in other industries where the atmosphere is not laden to such an extent with conducting material.

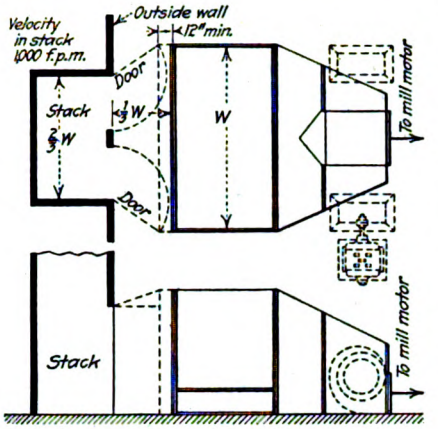
The best method of protecting a motor from this dust and dirt is to provide a motor house within the mill. When a motor house is provided it is easier to keep the apparatus clean and the mill men and unauthorized persons are kept away

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from the electric equipment. One of the most important things to consider in the installation of a motor house is to make certain that the air for ventilating purposes is taken from a clean source. In every case the motor room should be completely closed off from the mill and where clean air is not directly available, an air duct with a blower should be provided. It frequently occurs that it is not possible to obtain clean air in a steel mill so that ventilating systems are usually provided with air cleaners. The amount of air necessary to ventilate a motor depends upon its electrical losses. It is best to have the manufacturer specify the amount of air necessary, but as a general rule about 10 cu. ft. per minute per rated horsepower will be sufficient. Gas fumes as well as dust and dirt should be kept out of the motor room.

In laying out ventilating ducts, care should be taken to avoid sharp turns as these seriously interfere with the passage of air. The ducts should be made as straight as possible and of such dimensions that excessive air velocities will not be encountered. Velocities in the duct of about 2,000 ft. per minute have been found very satisfactory for this purpose.

It is advisable to provide two intakes for air, one arranged to take air from the inside of the motor room, the other from the outside of the building. This arrangement is necessary since, in the winter the air which is taken from the outside may carry snow and ice into the windings. If an air washer is used it may become clogged with ice. With the arrangement mentioned above, all or a part of the air can be taken from inside the motor room in winter weather. It is best to proportion the amount of air taken from each source so that the temperature in the duct is not below 50 deg. F. A single door or shutter arrangement should be provided for the two intakes and arranged so that in closing one shutter the other is automatically opened. This will prevent the possibility of both intakes being closed at the same time, depriving the motor of its ventilation. This door will serve as a damper for properly proportioning the amount of air taken from each source, the door being fixed in the proper intermediate position. The diagram on this page shows a suggested arrangement.

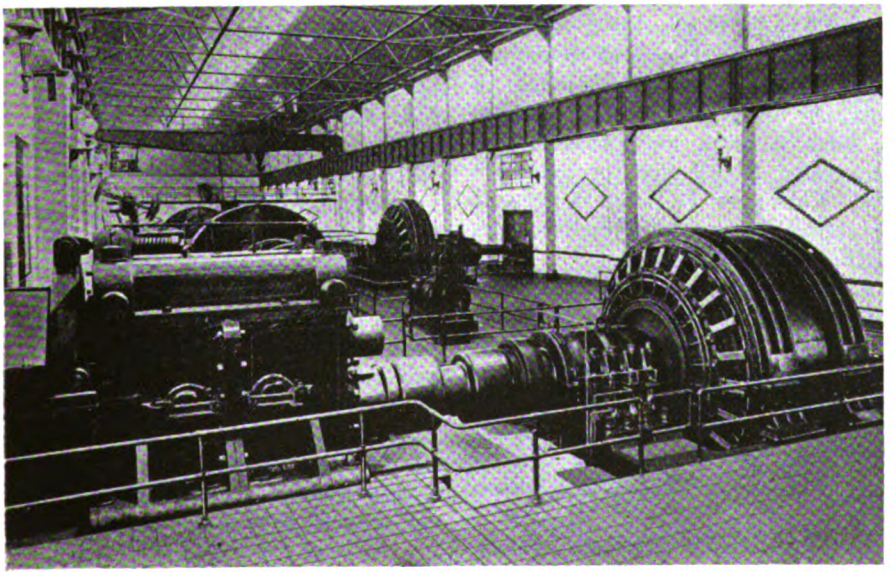


Here is a good arrangement of blower and air washer in a motor room basement.

Provision is made for taking air from outdoors through the stack as shown in lower diagram, which is an elevation view; or air may be taken through doors from the basement as shown in the top plan view.

When ventilating air is forced into the motor room the room should be designed with sufficient openings to provide free outlet for the air so that a pressure will not be set up in the room and the influx of air opposed, thus diminishing the amount of air given to the machines. A good plan is to install, near the roof, exhaust fans having sufficient capacity to expel approximately the same amount of air as is forced in by the blower. A slight pressure in the room is not objectionable as it prevents dust-laden air from coming in through doors and windows and other openings.

Sometimes it is not convenient to install a motor house. An instance of this kind is a hot-sheet mill. Some operators, in cases of this kind, have placed enclosing covers on the motors, provided a ventilating duct, and installed a blower and air washer for force-ventilating the motor with clean air. On page 423 is shown a motor so arranged with enclosing covers. The illustration on page 456 shows the blower and air washer. The duct is located under the collector rings. The diagram on page 424 shows how the duct is brought in.



This is a splendid example of a motor room that was laid out with the view of securing proper care and maintenance of the equipment housed therein.

Three large motors are located in this room, each of which drives main rolls located just outside of the room. The building is of brick and the walls and floor are of tile, thus dust does not readily enter and the room also is very easy to keep clean.

How to Prevent Sweating of Motors and Generators

Sweating is a result of a difference of temperature between the machines and the surrounding air. If the air is saturated at a certain temperature, and is cooled below this point it gives up some of its moisture. When the temperature of the machine is low enough to reduce the temperature of the air below the dew point all excess moisture is precipitated upon the machine. This is very injurious to the insulation. This phenomenon is frequently noticed on cold water pipes when the humidity is high. If the room temperature is kept uniform at all times or if the machines are kept slightly warmer than the surrounding air, sweating will be prevented. When the machines are installed, arrangement should be made to keep them slightly warm at all times. During periods of more or less extended shutdowns the machines should be covered by tarpaulins and

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a small amount of external heat applied to keep the machines at a temperature that will prevent sweating. Where high-voltage, alternating-current machines are installed in localities having high humidity, schemes have been worked up whereby 220-volt alternating current can be applied to the motor windings by simply switching the motor from its power line to the 220-volt shop circuit. This can be done very quickly and only a small amount of power is required. As the heat is applied internally, it is necessary to keep the temperature only a few degrees above that of the surrounding atmosphere to prevent precipitation. Some operators have arranged space heaters in the frames of large induction motors and others have arranged electric heaters made up from grids or have even used steam pipes under the motors to keep them warm during shutdown periods.

Recommended Methods of Cleaning and Painting Machines

After the machines are placed in regular service the entire equipment should be kept clean, particularly the insulation. It is advisable to keep all machines painted as the paint will not only be a benefit to the machines by preventing rust and making them easier to clean, but also will be an incentive to the operators and attendants to keep the motor room and apparatus neat and clean. In addition to painting the iron and steel parts of the machines, the exposed parts of the windings, and particularly the creepage surfaces over the insulation, should be gone over at least once a year with a good insulating varnish. Most of the air drying varnishes will dry in from 24 to 48 hours with a room temperature of approximately 25 degrees C. If a shorter time is necessary the varnish can be dried more quickly by covering the machines with a tarpaulin, leaving an opening at the top for moisture to escape and placing resistance grid heaters under the machines to raise the temperature to not more than 100 deg. C. This treatment will cause the insulation to become smooth and glossy so that dirt will not adhere readily. A baking varnish is to be recommended in preference to an air drying varnish if conditions are such that it can be applied. This requires a somewhat greater preparation as the machine should be covered over and heaters provided to keep the machine at about 100 deg. C. for 24 hours. Previous to applying any kind of varnish the insulation must be absolutely clean. The machine may first be thoroughly blown out with a moderate pressure air blast and then wiped thoroughly with rags saturated in alcohol to make certain that all oil and dirt are removed. These rags should be drawn through between the coils and all pockets should be thoroughly wiped out.

Analysis of Dust Found on Steel Mill Motor

Component Parts	Per Cent of Sample
Water	2.2
Carbon as coke dust, etc.	16.2
Silica as slag, sand, etc.	9.8
Iron oxide as scale and ore	63.0
Aluminum oxide	6.8
Calcium oxide	1.0

Of this sample, 81 per cent is good conducting material, which would tend to introduce creepage currents that would break down the insulation and cause a shutdown. It is for this reason that greater precautions must be taken in the maintenance of electrical equipment in steel mills than in other industries where the atmosphere is not laden to such an extent with conducting material.

Insulation Resistance Should Be Measured Periodically

Periodic inspection should be given to the entire equipment, say every week or so, at which time the machine should be thoroughly blown out with a moderate pressure air blast—about 25 to 30 lbs. per sq. in. is the most satisfactory. As the mill line is usually high pressure—on the order of 100 lb. per sq. in.—it is advisable to provide a reducing valve and water trap so as to obviate any danger to the insulation due to moisture or a high-pressure blast. In some cases a low pressure air compressor is installed for this purpose. Care must be taken to prevent dirt from getting into the bearings during this cleaning.

At occasional inspection periods, the insulation resistance should be measured while the machines are still warm, and a permanent record kept. This will show whether any deterioration of insulation is taking place, and preventive steps can be taken before an actual breakdown occurs.

The insulation resistance can be taken with a high-voltage megger or a 500-volt d.c. circuit and a high-resistance voltmeter. A megger or megohmer is the more convenient method of measuring insulation resistance. If a grounded direct-current, 500-volt circuit is used, care should be taken to see that the grounded side is connected to the frame of the machine. In using a megger or megohmer the instructions coming with the instrument should be carefully followed, or misleading and erratic results may be obtained. These readings should be taken when the insulation is warm and the insulation temperature recorded with the reading.

When using a high-resistance voltmeter and a 500-volt, d. c. circuit, one side of the circuit is connected to the frame of the machine and the other to the bare windings through the voltmeter. The insulation resistance may then be determined from the following equation:

$$R = [(V - v) \times r] \div V$$

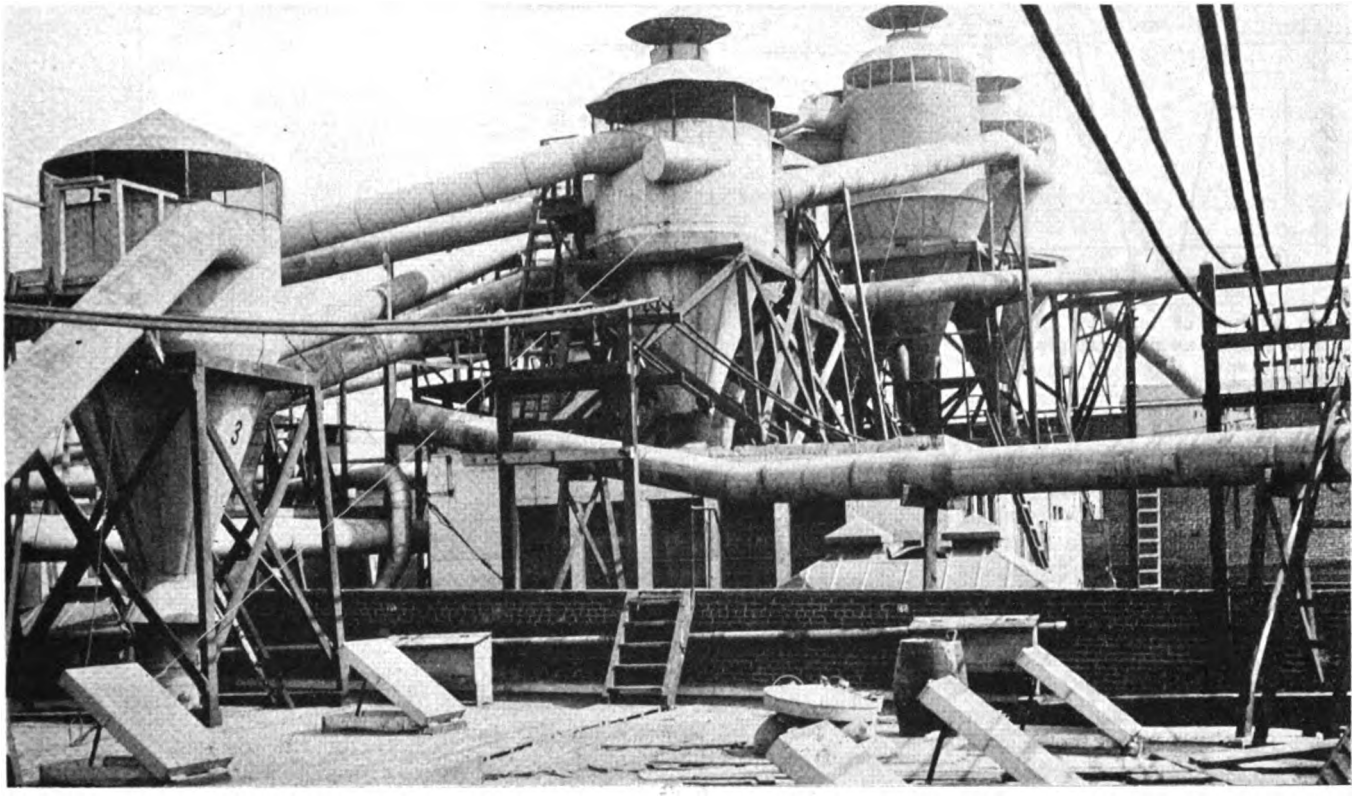
where R = the insulation resistance
r = the resistance of the voltmeter
V = the line voltage
v = the voltmeter reading.

The most positive method of measuring the ability of the insulation to withstand operating voltage is to apply actual potential tests on the insulation. This requires a small transformer testing box designed to give a wide range of voltages and having a capacity of about 1 kva. for each 1,000 volts rating of the high-tension side of the testing transformer.

The test voltage can be applied for a period of one minute and if a weak point is found, very little damage will be done, due to the small capacity of the transformer. On the other hand, if the apparatus is continued in service without discovering this weak point, the apparatus itself may be connected to a power circuit having considerable capacity and when the breakdown occurs, the large amount of power available may seriously damage the machine. Such a breakdown naturally occurs when the mill is in operation, and its delay is serious. If a testing transformer is used this can be done before the equipment is started up and the repair made before the mill is placed in operation. Before this voltage test is made, the machine should be blown out and all brass and copper parts wiped clean as the

(*Please turn to page 456*)

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This collection system is part of the pneumatic conveying installation which handles hemp, flax and other materials at the Brooklyn plant of the American Manufacturing Co.

Some Things It Pays To Know About

Handling Materials by Air in Industry

Such as the Equipment and Quantity of Air Required, the Different Materials Which May Be Handled in This Way and Some of the Advantages and Economies Resulting

By CHARLES L. HUBBARD
Mechanical Engineer, Boston, Mass.

PREVIOUS articles in this series, which have appeared in earlier issues of INDUSTRIAL ENGINEER, have taken up the removal of fumes, vapors and fine dust by means of pneumatic systems employing a fan for producing the necessary suction. In each instance the material removed is light and will remain more or less suspended in air in motion. This article will discuss the means employed for handling coarser waste material such as sawdust and shavings, powdered coal, wool, cotton, ashes and numerous other light materials.

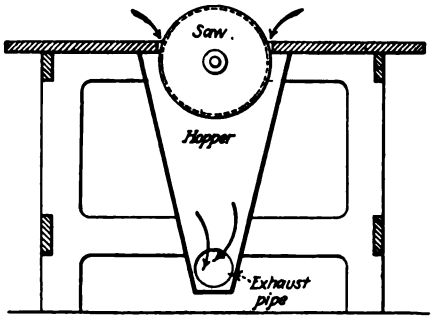
Dust and coarser waste are often produced in the same process, as in woodworking shops and similar industries, and if the coarser wastes are not too large or heavy are handled together. In some cases it is necessary to separate them, especially at saw mills and when dressing lumber where the sawdust and shavings are removed pneumatically and the coarser trimmings by some form of flight or belt conveyor.

PNEUMATIC HANDLING of materials is taken up in this, the fourth and last article of a series on the use of exhaust systems in industrial plants. Previous articles have discussed the removal of fumes and gases, and the collection and separation of dust. This article covers the handling of heavier materials such as shavings, wool, jute bagging, and materials in pulverized or semi-pulverized form.

The articles relating to the removal of fumes and dust have been closely connected with the ventilation problem and the health of the operatives. However, the handling of coarser materials relates more to the routine of manufacture, and may be applied equally well to conveying many types of raw materials into and sometimes through the process of manufacture, as well as disposing of the waste. This feature of pneumatic conveying will also be touched upon in the present article.

In general the handling of coarse material in woodworking shops, shoe factories, and so on, is accomplished in much the same way as the handling of the finer dust, except that special fans must be employed which are able to withstand blows from knots and splinters thrown from planing mills; and also to avoid clogging, as would be the case in handling long shavings from excelsior and shingle mills, wool, cotton and other fibrous products. Fans

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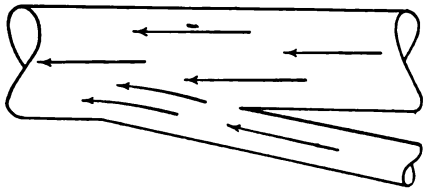


One method of locating the hood or hopper of an exhaust pipe for a circular saw.

are designed with particular reference to the material they are to handle. This should always be taken into consideration, when laying out an exhaust or pneumatic conveying system.

Shavings, sawdust, and so on, are removed through special hoods surrounding the cutting tools similar to those already described for collecting fine dust and fumes. An exhaust system for a woodworking shop differs from the pneumatic sweeper in the arrangement of its various parts, in that the separator, or collector as it is called, is generally placed on the discharge side of the fan instead of on the inlet side. For some pneumatic conveying, however, the separator is placed ahead of the exhaust fan.

The equipment used in the handling of waste in woodworking shops, with suitable modifications, is typical of that employed in other industries. Various woodworking machines require special forms of hoods according to their construction and the kind of work done by them. Drawings or prints showing the construction of the hoods are usually furnished by the makers of the machines. The construction of several types of hoods is shown in accompanying illustrations and the special features of each are described in the caption.

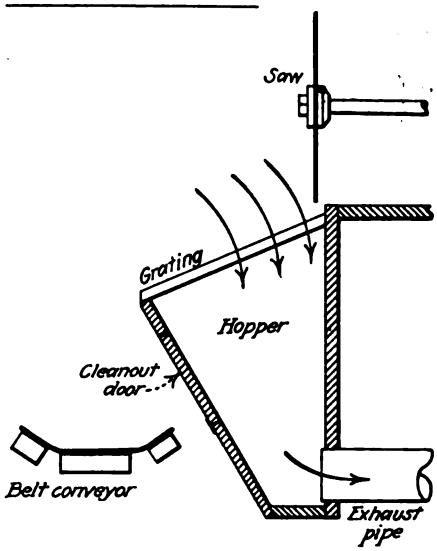


Inlets to hood exhaust ducts should be gradual to give a stream-line effect.

In general all hoods should be designed so as to provide the "streamline" effect and avoid eddy currents as much as possible. This calls for an easy flare at the entrance, and a gradual taper to the exhaust outlet. Also, particular attention should be given to the design so that the action of the cutter or saw will discharge the refuse into the hood in the direction of the flow of air and so assist the exhaust rather than retard its velocity.

The starting point in planning a system of this kind is at the machines and in the absence of more definite information from the manufacturer of a particular machine the dimensions for the pipe connections given on page 429 may be employed. In laying out a simple system of piping, as for the exhaust installation shown on page 430 it is well to make the main as straight and short as possible, and to cap the dead end so that it may be easily opened for inspection. Joints in the pipe should be lapped to offer no resistance to the flow of air nor edge to catch materials. The system should include as few elbows as possible, with the least radius not less than 1½ times the diameter of the pipe at that point.

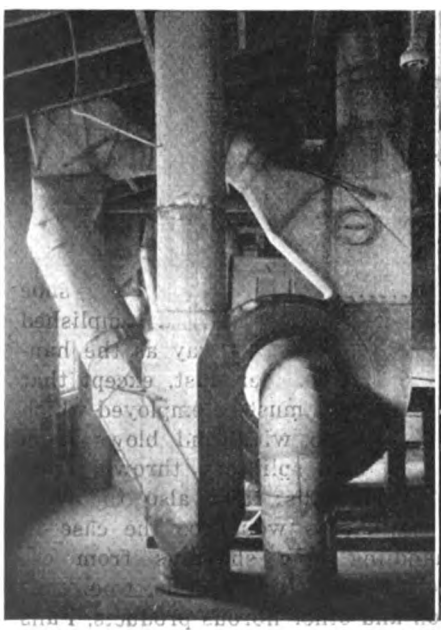
In addition to capping the dead end, as noted above, clean-out openings are provided at frequent intervals for removing obstructions, should they occur. When short vertical runs are necessary the area of

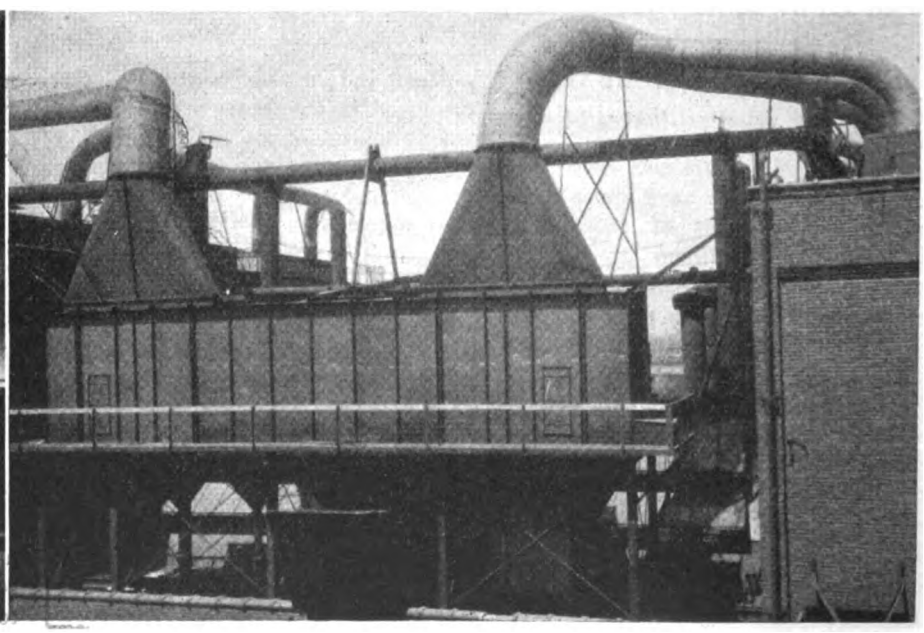


The sawdust is drawn through the grating in the hopper, which serves as a hood, and sawed-off ends or edges fall onto a conveyor.

Two views of the conveying and collecting systems at the Armstrong Cork Co.

The illustration at the left shows a complicated arrangement of pipes which enable the material to be distributed or collected from various locations. The illustration at the right shows one of nine large Sly dust arresters for collecting cork dust.





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the riser may be restricted somewhat, thus increasing the air velocity through this section and so adding to the lifting power. If the vertical pipes are comparatively long, they are kept the same diameter as the horizontal runs and the necessary lifting power secured by increasing the velocity throughout the entire system. The method of proportioning the pipe and fan sizes for an installation is explained in connection with the illustration of an exhaust system on page 430 and the table on page 431.

Blast gates should be placed in all exhaust connections and kept closed when the machines to which they lead are not in use, as this reduces the volume of air handled and prevents useless power consumption. This must not be done to such an extent, however, as to reduce the quantity of air passing through the main to a point where it falls below that necessary to carry the waste from machines still in use.

The air velocity through the exhaust ducts, which determines the suction, depends upon the kind of material to be handled, and usually runs about as follows: light shavings and sawdust, 2,500 to 3,500 ft. per min.; chips, bark, and so on, 3,000 to 5,000 ft. per min.; dust from leather and napping machines, 2,000 to 2,500 ft. per min.

Although the fans used in different exhaust systems are more or less of the same general type, modifications are frequently necessary to fit them for the special conditions under which they are to operate. For example, an ordinary mill waste, such as sawdust, planer chips, and so on, is handled by what is known as a standard mill exhauster, while long shavings from an excelsior mill require a special form of blade without projections on which the shavings may catch.

Recommended Diameter of Hood Connections

Type of Machine	Inches
Matcher heads, each	5
Sash and cabinet shaper, each head	4
Door tenoner	5
Sash tenoner	4
Door and sash sticker, each head	4
Blind slat sticker	4
Blind rail router	4
Panel raiser, each head	4
Sand drum 29 in. long	4
Sand drum 30 in. long	5
Sand drum 36 in. long	6
Sand drum 48 in. long	9
Sand drum 60 in. long	11
Belt sander up to 4 in. wide	4½
Belt sander 4 in. to 8 in. wide	5
Belt sander 8 to 12 in.	6
Disc sander up to 24 in. dia.	5
Disc sander 24 in. to 36 in.	6
Rip saws and resaws up to 14 in. dia.	4
Rip saws and resaws 14 in. to 18 in.	4½
Rip saws and resaws 18 in. to 24 in. dia.	5
Cutoff saws not over 16 in. dia.	4
Band saws up to 1½ in. wide	4
Band saws 1½ in. to 3 in. wide	4½
Band saws 3 in. to 4 in. wide	5
Band saws 4 in. to 6 in. wide	6
Buzz planers, molders, planers and all other machines having knives of dimensions given:	
Up to 6 in. long	4
6 to 8 in. long	4½
8 to 12 in. long	5
12 to 18 in. long	6
18 to 24 in. long	7
24 to 30 in. long	8
Floor sweep-up	6

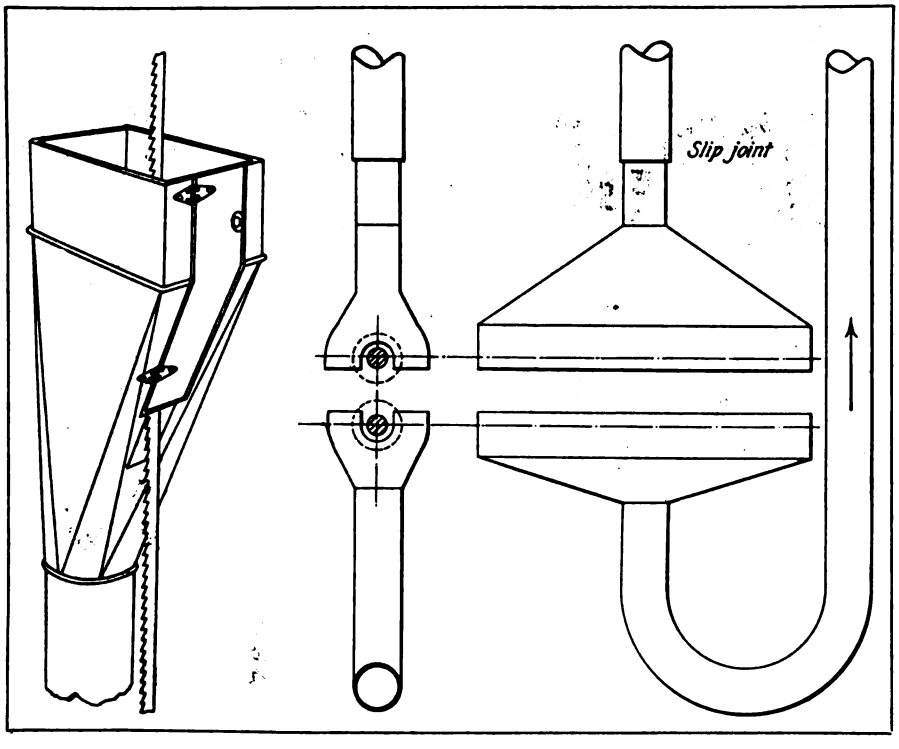
Fans for handling other materials, such as cotton, wool, strips of paper, jute bagging, excelsior, and so on, require still different construction. Steel plate casings are commonly used for the large sizes and cast-iron for the smaller. Where head room is limited and the main exhaust pipes come from opposite directions, it is often better to use two fans, which may be driven by one motor, as this eliminates elbows and the pipes run directly into the fan inlets.

Accurate methods for determining the size, speed and power of the fan should be used in laying out large and important systems. Computations of this kind, however, are best left to the engineers making a specialty of such equipment. Estimates for preliminary work, and for small layouts and extensions, can be made from tables and simple data found in the catalogs of most fan manufacturers. The table on page 431 gives some of this data. A simple example showing how to use it is given in the caption accompanying the table.

It will usually be found from a complete table of this kind that the work required comes within the range of two or three different sizes of fans, and that a selection may be made between smaller sizes operating at a higher speed or a larger fan operating at a lower speed. The latter often results in a lower operating cost and less vibration, although the first expense of installation is somewhat greater.

It should be remembered that the output of the fan which is dependent upon the velocity of the air, increases as the speed (r.p.m.) but the pressure increases in proportion to the square of the speed and the power required increases in proportion to its cube. It is well to consider this feature if it is at all likely that at some future time it will be desired to add machines to a line. A slight additional capacity in the fan will provide for this. To obtain increased capacity by operating a fan above its rated capacity and speed is possible only at the expense of a heavy increase in the power required to operate the equipment.

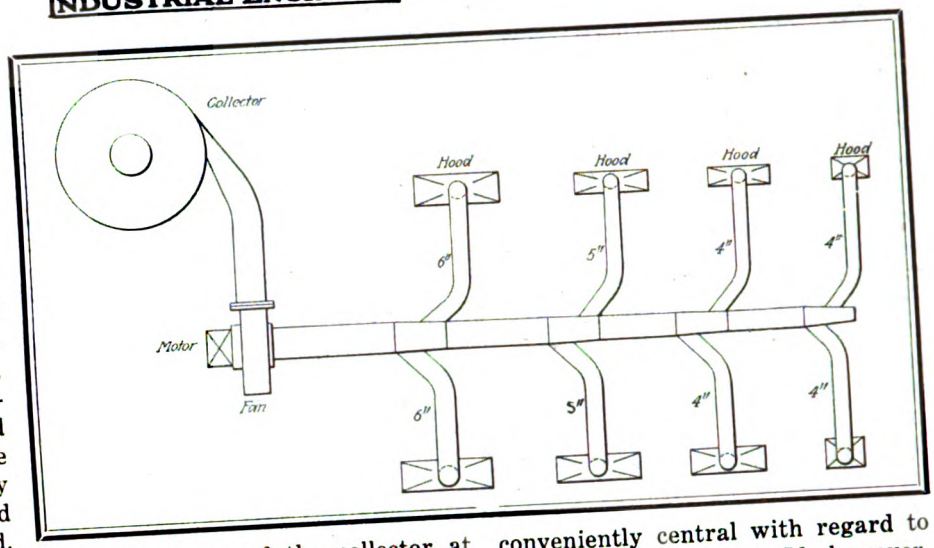
Exhaust fans are belted to the line



Two types of hoods used on special machines.

The hood at the left is made of sheet iron and fits under a band-saw table to carry away sawdust. The illustration at the right shows a double hood to be used in connection with a planer. The upper hood telescopes in a slip joint for adjustments and repairs.

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A diagrammatic sketch of a typical woodworking installation.

Here chips or shavings are drawn away from each machine through its hood into a main duct which discharges directly into the exhaust fan and are then blown into the cyclone collector. Some of the computations used in determining the size of fan for this installation are discussed in the explanatory matter in connection with the table on the opposite page.

shaft or to individual electric motors and, under certain conditions, are driven by direct-connected motors or engines. The best method of driving in any particular case depends on local conditions, and any of these mentioned should give good results wherever it is well adapted. The direct-connected unit is very satisfactory where the required speed of fan is not so great, as to require the use of special a.c. motors or other equipment.

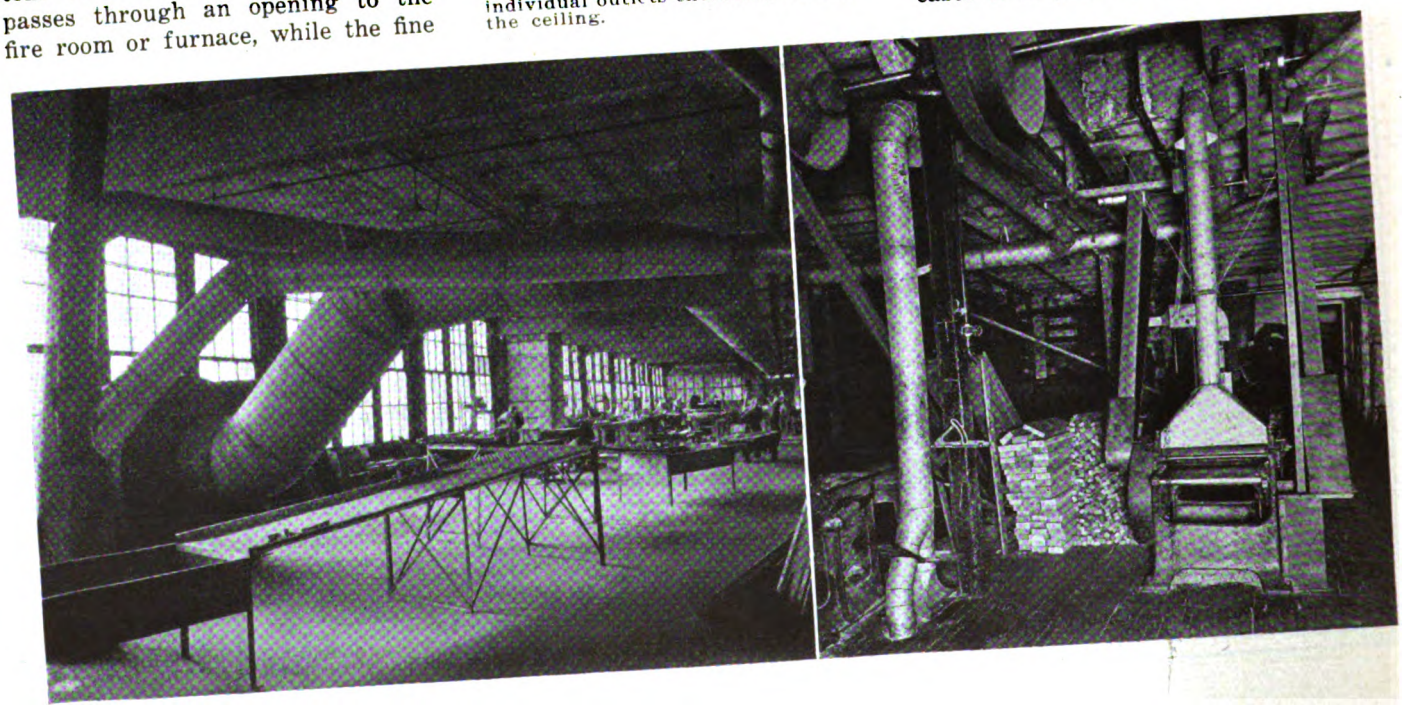
When handling shavings and similar waste material the exhauster discharges into a collector which is commonly known as a cyclone separator. This is merely a circular chamber which serves to separate the air and the finer dust from the coarser material and thus prevent the strong drafts of air and clouds of dust which would result if it were not used. This device is simply a chamber of conical form in which the fan discharges tangentially near the top. As the mixture of air and fine and coarse material enters the chamber the pressure drops, which destroys the air velocity, and separates the fine dust from the coarser waste. The latter falls to the bottom of the cone, and from here passes through an opening to the fire room or furnace, while the fine dust passes out of the collector at the top with the air. The size and proportions of the collector vary somewhat with different makes and with the character of the material to be handled. In general, the inlet is made the same size as the discharge from the exhauster, or slightly larger, and the air outlet of such size that the low air velocity thus produced will carry but a small amount of dust with it.

The exhauster should be placed nearest the heaviest work, but yet conveniently central with regard to all of the machines. If, however, there are a large number of hoods to be taken care of, so that an extremely large unit would be required, some form of relay system is commonly employed. In this case the machines are conveniently grouped and each section is provided with its own fan collector. The refuse from the several collectors may then be carried to a final collector by means of a special exhauster, or the refuse from the first collector may be discharged into the inlet of the second fan, and so on, until the refuse is all relayed to the final collector which discharges into the fire room. In planing mills it is often possible by this means to reduce by one-half the diameter of the long discharge duct leading to the main collector.

Exhaust piping is commonly carried overhead, although in some cases it may be more convenient to

Installation for handling shavings in woodworking plants.

The illustration at the right shows the exhaust connections and hoods around woodworking machinery. The hood on the planer telescopes for adjustment or for repairs to the planer. The floor sweep-up at the left of the planer, which may be cut off by a blast cap, facilitates the rapid removal of sweepings. The illustration at the left shows the exhaust system in the woodworking department of a large automobile concern. Here the exhaust ducts are arranged on the ceiling of the floor below the machines with individual outlets extending through the ceiling.

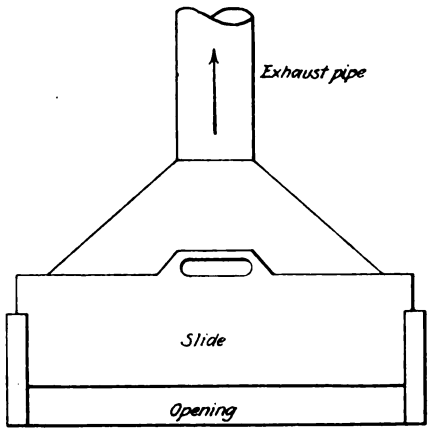


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run it on the ceiling below which, however, necessitates cutting through the floor for each machine While this might not be objectionable for permanent installations, it has its disadvantages where the layout may be shifted frequently.

The systems described for woodworking shops are typical of those employed in other establishments where refuse of a similar nature must be handled, as in shoe factories, grinding and polishing processes, and so on. Differences in equipment are principally confined to minor details of construction and operation, such as type and speed of fan, air velocity in ducts, size and form of collector, and so on.

Any material which is light enough so that it can be made to remain suspended in air for a time, may be carried along on an air current of sufficient volume and velocity. This has led to many large installations of pneumatic conveyors. The materials so handled may be divided in general into two classes: Those which are either finely pulverized or would become pulverized and give off a dust when handled, and those which would need to be baled or bundled to be handled economically.



A type of floor sweep-up in which the slide at the opening serves as a blast gate.

Some of the materials of this first class which are handled economically by air are: both granulated and pulverized cork, fertilizers, lithopone (both in powdered and lump form), arsenic as a byproduct of smelting ore, either rock or pulverized phosphate, bauxite, soda ash, white clay, powdered coal, and many other similar materials and products. Many of these materials mentioned would create a very objectionable and in some cases poisonous dust if handled by a man with a shovel, or by a grab bucket, or by any of the other common means of handling and conveying raw material; in some cases it would be almost impossible for a man to work under the conditions created. Air conveying creates practically no dust, as will be explained later.

Materials of the second class which would have to be bundled to be handled economically are: cotton, wool, jute bagging, hair, flax, hemp, shoddy, waste paper, tan bark, wood or paper pulp, grains and feeds, coffee and many other products. Although some of these are shipped and handled in bags, bales or bundles, it is often uneconomical to rehandle them loose by the common means of conveying particularly such materials as cotton, rags, waste paper, and so on, when moving between machines or processes or in or out of storage. It would be very expensive to bundle each time and this would not always be desirable after such operations as picking or cleaning cotton or wool.

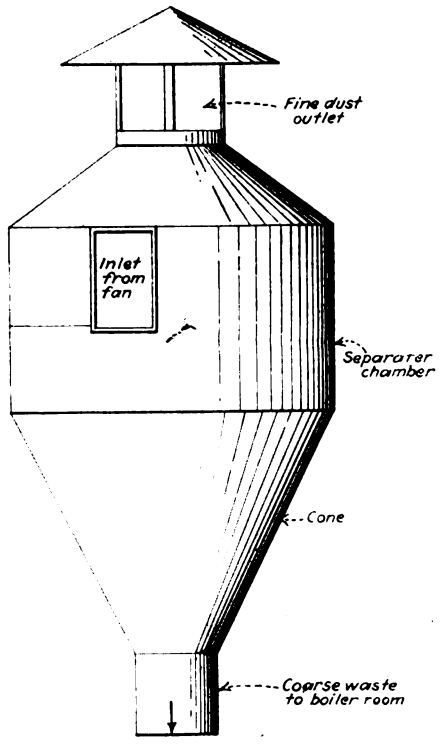
Pneumatic conveying generally is done in one of three ways. The most common type of pneumatic conveyor consists of an inlet, ducts, exhauster or blower and a separator. This is practically the same equipment as is required in the methods

(Please turn to page 454)

Manufacturer's Rating Table for Determining Capacity and Other Specifications of Fans

Fan Size	Diameter of Main—Inches	Area of Main—Square Inches	SUCTION 3.0 Inches			VELOCITY 3880 Feet per Minute			SUCTION 3.5 Inches			VELOCITY 4190 Feet per Minute			SUCTION 4.0 Inches			VELOCITY 4480 Feet per Minute			SUCTION 4.5 Inches			VELOCITY 4750 Feet per Minute			SUCTION 5.0 Inches			VELOCITY 5010 Feet per Minute		
			Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power	Revs. per Min.	Cu. Ft. per Minute	Horse-power
30	12	85	1496	2843	6.00	1619	3072	7.43	1728	3280	9.18	1833	3485	11.00	1931	3670	12.90														
	13	99	1492	3320	6.24	1614	3585	8.56	1724	3840	10.40	1827	4070	12.50	1925	4285	14.70														
	14	112	1487	3795	7.76	1610	4100	9.80	1717	4380	12.00	1821	4645	14.30	1918	4895	16.70														
	15	127	1485	4262	8.90	1607	4605	11.20	1715	4920	13.60	1820	5220	16.30	1916	5503	19.10														
	15	141	1490	4749	10.10	1611	5125	12.80	1720	5478	15.50	1825	5830	18.50	1920	6138	21.70														
35	14	115	1285	3865	8.15	1390	4180	10.10	1486	4460	12.47	1592	4740	14.92	1658	4990	17.45														
	15	134	1282	4520	9.26	1386	4875	11.63	1482	5220	14.15	1572	5535	17.00	1654	5830	19.90														
	16	153	1279	5160	10.57	1381	5536	13.30	1478	5960	16.23	1566	6320	19.36	1651	6655	22.70														
	17	172	1277	5796	12.05	1380	6260	15.15	1476	6690	18.52	1553	7100	22.10	1649	7490	25.95														
	18	192	1280	6455	13.70	1385	6970	17.30	1480	7450	21.05	1568	7925	25.20	1652	8340	29.45														
40	16	150	1125	5050	10.65	1217	5460	13.20	1300	5830	16.30	1378	6190	19.50	1452	6520	22.80														
	17	175	1122	5900	12.10	1214	6370	15.20	1296	6820	18.50	1374	7230	22.20	1447	7620	26.00														
	18	200	1119	6740	13.80	1210	7280	17.40	1292	7780	21.20	1370	8250	25.30	1442	8690	29.70														
	19	225	1170	7570	15.80	1208	8180	19.80	1290	8740	24.20	1368	9270	28.90	1440	9780	33.90														
	20	250	1120	8430	17.90	1212	9100	22.60	1294	9730	27.50	1372	10350	32.90	1444	10900	38.50														

NOTE: This table is based on average conditions for one particular type of fan, and takes into account the suction required at the hoods, the friction loss in the piping, and the resistance of the collector. The first column in the table gives the manufacturer's number corresponding to the size of the fan; the third column, the combined area of all the branches; the second column, the required diameter of the exhaust main, which corresponds to an area of 25 per cent in excess of that in column three. All other quantities in the table are clearly indicated. In the layout shown in the sketch on the opposite page, the combined area of the pipe branches to hoods is found to be 147 sq. in. The table shows that this corresponds closely to a 16-in. main, and may be cared for by a Size 35 fan If a velocity of 3,500 to 4,000 ft. per min. is required to carry the material to be handled in this case the speed and horsepower required may be taken with sufficient accuracy from the column headed "Suction 3 in., Velocity 3,880 ft." The table shows that a Size 35 fan should run at 1,279 r.p.m. and will require 10.57 hp. to operate it. This table is only a small section of the fan data supplied by the manufacturer.



Cyclone separators such as this are used for collecting shavings and other materials where it is not objectionable to discharge fine dust into the atmosphere.

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Here Are Some

Practical Pointers on Winding D. C. Armatures

Together With Directions for Taking Data and Marking Armatures to Prevent Errors in Rewinding and in Connecting Leads to Commutator

By A. C. ROE

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and

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Consulting Editor, Industrial Engineer

WHEN REWINDING armatures, careful recording of winding data and the observance of certain rules and principles are essential safeguards against costly mistakes. Furthermore, unless the winding data are put down in some systematic manner so that they will be easy to understand and use, serious confusion may arise and result in errors that are expensive to rectify. In this article, examples are given showing how to use the data forms which were shown in the June and July issues. In addition, there are described some simple methods of taking certain data and marking the commutator and core so as to insure that the armature will be properly rewound and connected.

IN THE article in the August issue directions were given for the proper use of the forms described and shown in the June and July issues, for taking and recording rewinding data on wave- and lap-wound armatures. In addition, there were also given some handy rules and principles, observance of which will help to prevent mistakes when rewinding and connecting armatures having these types of windings. The present article deals with the methods of taking rewinding data and marking the armature so as to insure that it will be properly rewound and connected.

Identification Markings for Core and Commutator

The first step in taking winding data is to note the nameplate rating, customer's name and order number; then take the number of bands, width, and size of wire, and any other dimension data deemed necessary for rebanding, such as size of tin strip under core bands, and of the fiber strip on top of the coils to prevent the bands from cutting into the insulation. Next, remove all wire, tape, and core bands, and slot wedges, if used. Then count the number of slots and bars, record these on the data sheet in the proper place, and mentally check the number of bars against the number of slots.

For example, if a four-pole armature has 41 slots and 81 bars, the number of bars being one less than twice the number of slots, this would indicate that a dead coil was used, which should be located and used for checking the lead throw and pitch. On the other hand, if the four-pole armature has 41 slots and 82 bars, an even number, this would indicate that a half-idle bar was used. These points can be checked mentally, while writing down the number of bars and slots. Next, locate the dead or half-idle coil, or if none is used, select any coil and mark the teeth on either side of the slot that contains the *top* half of the coil with two cross marks. (See slot *B* in Figs. 1 *I* to 1 *XII*). Then with an odd number of coils per cell, (Figs. 1 *III* and 1 *V*), or with an even number of coils per cell and a dead coil (Fig. 1 *II* and 1 *IV*) select the middle top lead and trace it out to the commutator and mark the bar to which the lead connects with two center-punch dots as shown in Fig. 1 *IV*, bar *F*. These marks should be placed on the front of the commutator bar near the V-ring.

Next determine whether the winding is progressive or retrogressive. This can be done without knowing the lead pitch as follows: Lift the top lead from the bar just marked and bend it back so that it can easily be picked out again without marking it, and lift two top leads on either side of bar *F*. Then with one test light lead on the top lead that connected to bar *F*, touch the other test lead to the commutator bar on either side of and adjacent to bar *F*. If a light is obtained from the bar to the left of bar *F*, (facing the commutator end of the armature), the winding is retrogressive, and the lead pitch (in bars) will be the total number of bars, minus 1, divided by one-half the number of poles. If a light is shown on the bar to the right of bar *F*, the winding is progressive, and the lead pitch (in bars) will be the total number of bars plus 1, divided by one-half the number of poles. This will locate the commutator lead pitch, *CF*. Call bar *C* No. 1 and add the lead pitch in bars. This will give the number of bar *F*. For example, take the case of a 33-slot, 65-bar, progressive four-pole armature. The lead pitch equals $(65+1)\div 2=33$. Then *F* equals 1+33, or 34. The lead pitch can be checked and also located by lifting the top lead from bar *F* and the two adjacent bars on either side of bar *F*, as explained above, and holding one test light on the top of the lead of bar *F*, with the other test lead on the commutator about half-way around from bar *F*, for a four-pole machine, one-third of the way around for a six-pole, one-fourth of the way around for an eight-pole, etc. Move this test lead back and forth until contact is made with a bar that lights. When a light is obtained, try the bar on either side of the one on which a light showed up. This will indicate any shorts, etc., in the commutator or coil, which would throw the lead pitch check off. A light should be found on only one bar, and this is the bar to which the bottom lead connects. Mark this bar with two dots, as shown under bar *C*, Fig. 1 *IV*. Next, count the bars between *C* and *F*, calling bar *C*, No. 1. If bar *F* is number 35, the lead pitch will be one less than the number of bar *F*, or 34, expressed in bars, or 1-and-35 for laying off coil throw.

In counting the lead pitch on the commutator, care must be taken to

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count in the right direction, particularly on four-pole armatures. For a left-hand coil, count from the top lead bar in a clockwise direction around the commutator, and for a right-hand coil count in a counter-clockwise direction. In both of these cases and in all future cases, we will assume that we are looking at the armature from the commutator end.

Fig. 2 shows the possibility of two lead pitches as mentioned above. In Fig. 2, assume that coil *A* with a lead pitch of 1-and-9, is the correct coil (left-hand). If the lead pitch had been counted off in a counter-clockwise direction, as indicated by the figures in the small circles, we would arrive at bar *9*, but the count would be 1-and-8, as shown by the light line marked coil *B*. This is a short pitch which is the winding term for a retrogressive winding, whereas the proper winding requires a long pitch or progressive winding.

Having located the top and bottom lead bars and also the top slots, the next step is to locate the slot in which the bottom half of the data coil lies, or slot *A*, Figs. 1 *I* to 1 *XII*. In some cases the coil can be traced across the back of the armature to the bottom slot. In other cases it will be necessary to lift up enough top coils to be able to trace out the coil and locate slot *A*, which should be marked by stamping an X on a tooth on either side of the slot, as shown. Next, take a piece of string and line-out with it from the center of slot *A* to the commutator, using the center mark in the end of the shaft for a point to insure a straight line from the slot center. Then, if this line falls on a bar, mark this bar with one center-punch mark, as shown in Figs. 1 *I*, 1 *III* and 1 *V*. If the line-out falls on the mica, mark the bars on either side of this mica with one center-punch dot, as in Figs. 1 *II*, 1 *IV*, 1 *VI*, and 1 *IX*. By marking the bars on a line with the bottom slot of the data coil, all chance for a wrong lead pitch is eliminated, as the marked bar, *D*, locates the coil on the proper side of the armature and in the proper relation to bars *C* and *F*. The distance *C D* is the throw of the bottom lead and should be marked as 1-and-12, 1-and-9, etc., as the case may be.

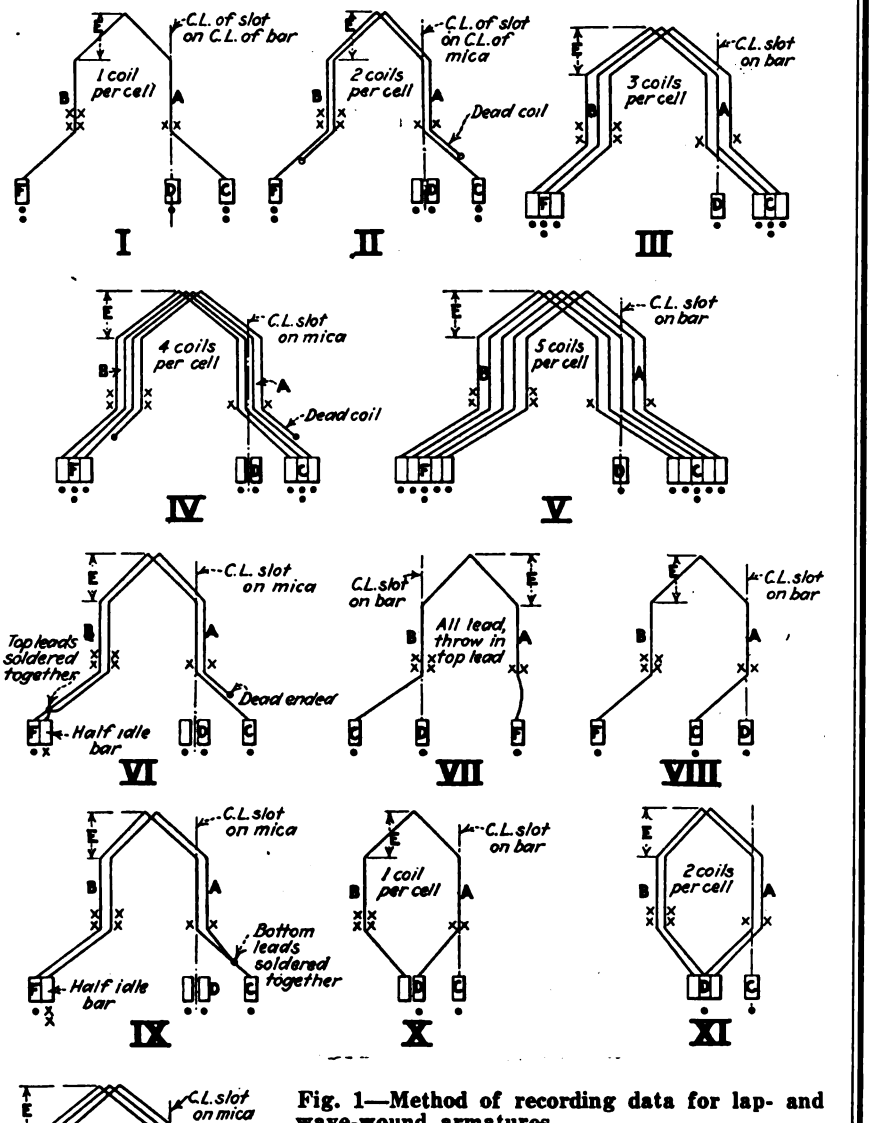


Fig. 1—Method of recording data for lap- and wave-wound armatures.

The slot holding a bottom coil side of any coil is marked with one cross on each tooth, as slot *A* in each diagram. A slot holding a top coil side of any coil is marked with two crosses on each tooth, as slot *B* in each diagram. The dots beneath certain bars represent center-punch marks to distinguish the bars connected to coils lying in slots marked with crosses. With more than one coil per cell, two punch marks are used to indicate bars belonging to one coil.

The reason for marking the commutator on a line with the bottom half of the coil and not with the top half is that the winding data are taken in the opposite manner to that used in placing the new coils in the armature. When winding the armature, the first coil has its bottom leads put in the proper bar. If a dead coil or half-idle bar is used, the first coil in should be used to make the required type of idle coil. If the top slot is used to line-out from, the winder would have to put his coil in, then line-out and count over to bar *F*, and then back to bar *C*, but with the marking shown in Fig. 1, as explained above, the winder first locates the marked teeth and puts the bottom half of the coil in the slot between the teeth marked with one cross. He then puts the proper lead in the marked bar. In this way it is not necessary to line-out and count over, as this has been done and the bars permanently located with the core and commutator markings.

After locating the main bars and slots as already explained, mark the bars adjacent to bars *C* and *F* with one punch mark to indicate the number of active coils per slot, and also the position of the data coil in relation to the other coils in the same cell. Figs. 1 *VI* and 1 *IX* show how to mark the bars for a half-idle bar. Two cross marks on one bar indicate that the long jumper is used, as in Fig. 1 *IX*.

For other examples of bar and slot markings, see Figs. 3, 4, 5 and 6, July issue, pages 334, 335 and 336. The accompanying table gives the coil pitch and long and short lead

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pitches for the usual numbers of slots and bars used on four-pole machines.

Method of Checking Lead Pitch for Wave Windings

In what follows an easy method of finding and checking the lead pitch of a wave winding will be given. As already mentioned, the first rule to be memorized is that in any wave winding a series of coils equal to one-half the number of poles will encircle the armature; and this series must end either one bar ahead of or one bar behind the bar that the series started on. This series should never end on the same bar it started on, for then the winding will close on itself the first time around the armature. Then, on any four-pole machine, with a given number of bars we know that a series of $4 \div 2 = 2$, coils, will encircle the commutator, ending on a bar plus or minus one bar from the starting bar.

For example, assume 55 bars and add 1 or subtract 1 from 55. First add 1; then $55+1=56$. The leads of each coil will span a little more than one-half the commutator, or $56 \div 2 = 28$ bars. To check this, call any bar No. 1; then add 28 to it and 28 again to this answer, or $1+28+28=57$. We have only 55 bars, but if we continued counting, bar *1* would be bar *56* and bar *2* would be *57*. Then from this check, if we use a lead pitch of 28, and start the series on bar *1* it will end on bar *57*, or bar *2*, which is one ahead of the starting point and is O. K. Next, subtract 1 from 55, which leaves 54. Then $54 \div 2$ gives a lead pitch of 27 bars, or starting on bar *1* and adding 27 and then 27 again, we arrive at bar *55*, which is one bar behind the starting point and is satisfactory. Thus we find that with a given number of bars on a four-pole machine, there are two possible lead pitches, one long and one short.

Next, suppose we have a six-pole armature having 100 bars and wish to find the lead pitch in bars. With six poles there will be a series of $6 \div 2 = 3$ coils that must end one bar ahead of or behind the start. Then adding 1 gives 100+1, or 101, and $101 \div 3$ equals 30 2/3 which will not work, since the lead pitch must be a whole number. Next try subtracting 1, or $100-1=99$, and $99 \div 3 = 33$. With a lead pitch of 33, adding to bar *1*, $1+33+33+33=100$. By starting the series on bar *1* and using three coils with a lead pitch of 33, the series will end on bar *100*, which is one behind the starting point, and will result in a retrogressive winding.

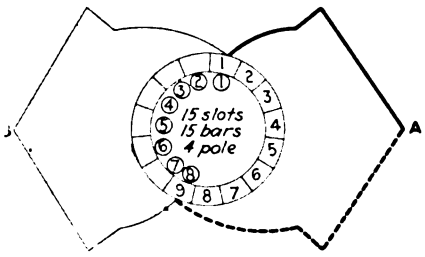


Fig. 2—This diagram shows how two lead pitches are possible.

Assume that coil *A* is left-handed and is the correct coil, having a lead pitch of 1-and-9, counted in a clockwise direction. If the lead pitch were counted in a counter-clockwise direction, as shown by the figures in the small circles, bar *9* would be reached, but the count would be 1-and-8 as shown by the coil marked *B*. In the latter case the winding would be retrogressive, whereas it should be progressive. When counting the lead pitch for a left-hand coil, proceed in a clockwise direction, from the top lead bar. When dealing with a right-hand coil, count counter-clockwise.

A progressive two-circuit winding cannot be used with 100 bars, which brings out the fact that on a six-pole machine and with a given number of bars, only one workable, two-circuit lead pitch is obtainable. The reason for using the term "two-circuit" will be explained later.

Next, we will try a six-pole, 200-bar commutator, and try to determine the lead pitch. First try minus 1 or $200-1=199$, and $199 \div 3 = 66$ 1/3, which will not work. Next, try plus 1, or $200+1=201$, and $201 \div 3 = 67$. Then add to bar *1* three times 67, or $1+67+67+67=202$. With 200 bars, No. 202 will fall on bar *2*, which is one ahead of the starting bar, No. 1, and will give a progressive winding. This brings out a condition met with on a six-pole machine; that is, doubling the number of bars will change the winding from retrogressive to progressive or vice versa. If we want to double the voltage by doubling the number of bars, the type of winding will be changed, or we can make the new number of bars equal to twice the old, less one. In the case just mentioned $(100 \times 2)-1=199$ bars, and the lead pitch will be $(199-1) \div 3 = 66$, or $1+66+66+66=199$, which gives a retrogressive winding that will require a dead coil. Thus

Coil and Lead Pitches for the Number of Slots and Bars Most Used on Four-Pole Armatures

No. Slots	No. Bars	Coil Pitch	Lead Pitch: Progressive	Lead Pitch: Retrogressive	No. Slots	No. Bars	Coil Pitch	Lead Pitch: Progressive	Lead Pitch: Retrogressive
23	115	1-6	1-59	1-58	47	47	1-11	1-25	1-24
25	75	1-7	1-39	1-38	47	93*	1-11	1-48	1-47
25	125	1-7	1-64	1-63	47	141	1-11	1-72	1-71
27	135	1-8	1-69	1-68	47	187*	1-11	1-95	1-94
					47	329	1-11	1-166	1-165
29	87	1-8	1-45	1-44					
29	115*	1-8	1-59	1-58	49	49	1-12	1-26	1-25
29	145	1-8	1-74	1-73	49	97*	1-12	1-50	1-49
					49	147	1-12	1-75	1-74
31	31	1-8	1-17	1-16	49	195*	1-12	1-99	1-98
31	61*	1-8	1-32	1-31	49	245	1-12	1-124	1-123
31	93	1-8	1-48	1-47					
31	123*	1-8	1-63	1-62	53	53	1-13	1-28	1-27
31	155	1-8	1-79	1-78	53	105*	1-13	1-54	1-53
31	217	1-8	1-110	1-109	53	159	1-13	1-81	1-80
					53	211*	1-13	1-107	1-106
33	65*	1-9	1-34	1-33	53	265	1-13	1-134	1-133
33	99	1-9	1-51	1-50					
33	131*	1-9	1-67	1-66	55	55	1-13	1-29	1-28
33	165	1-9	1-84	1-83	55	109*	1-13	1-56	1-55
					55	165	1-13	1-84	1-83
35	69*	1-9	1-36	1-35					
35	105	1-9	1-54	1-53	57	57	1-14	1-30	1-29
35	139*	1-9	1-71	1-70	57	113*	1-14	1-58	1-57
					57	171	1-14	1-87	1-86
37	73*	1-10	1-38	1-37					
37	111	1-10	1-57	1-56	59	59	1-14	1-31	1-30
37	147*	1-10	1-75	1-74	59	117*	1-14	1-60	1-59
37	185	1-10	1-94	1-93	59	177	1-14	1-90	1-89
39	77*	1-10	1-40	1-39	61	61	1-15	1-32	1-31
39	117	1-10	1-58	1-57	61	121*	1-15	1-62	1-61
39	155*	1-10	1-79	1-78	61	183	1-15	1-93	1-92
39	195	1-10	1-98	1-97					
					65	129*	1-17	1-66	1-65
41	41	1-11	1-22	1-21	65	195	1-17	1-99	1-98
41	81*	1-11	1-42	1-41	69	207	1-17	1-105	1-104
41	123	1-11	1-63	1-62					
41	163*	1-11	1-83	1-82	71	71	1-17	1-37	1-36
41	205	1-11	1-104	1-103	71	141*	1-17	1-72	1-71
					71	213	1-17	1-108	1-107
45	89*	1-11	1-46	1-45					
45	135	1-11	1-69	1-68					
45	179*	1-11	1-91	1-90					
45	225	1-11	1-113	1-112					
45	315	1-11	1-159	1-158					

*Indicates one dead coil.

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on six-pole machines and with a given number of bars, only one, two-circuit winding pitch is possible, and the progressiveness depends upon the number of bars.

Next, consider an eight-pole wave winding, which will have a series of $8 \div 2 = 4$, coils, encircling the commutator, plus or minus one bar from the start. With 199 bars the lead pitch will be $(199+1) \div 4 = 50$, or 1-and-51. For a check, add four times the lead pitch in bars (50) to bar No. 1. Then, $1+50+50+50+50 = 201$, or bar No. 2, which is one ahead of the starting bar and results in a progressive winding. A retrogressive winding is not possible, since $(199-1) \div 4 = 49\frac{1}{2}$. By using a half-idle bar, 200 bars and 100 slots could be used.

Now try 398 bars, or $(398-1) \div 4 = 99\frac{1}{4}$, which will not work. Next try $398+1$; then $399 \div 4 = 99\frac{3}{4}$ which will not wind, either. With 100 slots there would have to be 399 bars, or $(399+1) \div 4 = 100$, or a pitch of 1-and-101, giving a progressive winding which would require a dead coil; or 400 bars and a half-idle bar could be used.

The above points are brought up since they are important when considering a voltage increase with double the number of bars.

The following rules pertain to wave windings with reference to the relation of the coil pitch, coils per cell, lead pitch, and their effect on the line-out.

(1) On four-pole machines, when an odd number of slots is used with an even number of coils per cell, there will always be either a dead coil and one bar less than twice the number of slots, or there will be twice as many bars as slots and a half-idle bar. With an even number of slots and an even number of coils per cell, the above rule will also apply.

(2) With an odd number of slots and an odd number of coils per cell, the resultant number of bars will wind without the use of a dead coil or a half-idle bar.

(3) For six poles, with an odd number of slots and an even number of coils per cell, or with an even number of slots and an odd number of coils per cell, a dead coil or a half-idle bar will have to be used. When the resultant number of bars can be divided by 3 without a remainder, the winding will be progressive. When the number of bars is not divisible by 3, but the —1 sign will reduce the bars to a number divisible by 3 without a remainder, the winding will be retrogressive and will not require a dead coil or half-idle bar to make it wind.

(4) With eight poles, the number of bars plus or minus 1, with or without a dead coil or half-idle bar, divided by 4, should result in a whole number. This is the deciding factor on eight poles and above.

The following rules are used in conjunction with Fig. 3*A*. The lead and coil pitches should be expressed in bars and slots; that is, 55, 7, etc., and not 1-and-56 or 1-and-8, etc.

(1) The center line of the coil will fall on a tooth and bar when the coils per cell are odd, coil pitch odd, and lead pitch even, all three being considered together; or with coils per cell even, coil pitch odd and lead pitch odd.

(2) The center line of the coil will fall on a tooth and mica, with coils per cell odd, coil pitch odd and lead pitch odd, or with coils per cell even, coil pitch odd and lead pitch even.

(3) The center line of the coil will fall on a slot and bar with coils per cell odd, coil pitch even and lead pitch even, or with coils per cell even, coil pitch even and lead pitch odd.

(4) The center line of the coil will fall on a slot and mica with coils per cell odd, coil pitch even and lead pitch odd, or with coils per cell even.

The location of slots *D*, *E*, *F*, Fig. 3*A*, is found as explained for Fig. 2, August issue, page 381.

The method of locating bars *M*, *N*, *P*, and *S* (Fig. 3*A*), is found as explained for Fig. 2, August issue, page 381.

The method of locating bars *M*, *N*, *P*, and *S* (Fig. 3*A*,) is explained in the following rules:

(1) In all cases where the center line of the coil falls on a bar, the number of bar *S* is equal to the lead pitch (in bars) plus one more than the active coils per cell in the bottom of slot *A*, divided by two. Note that the term "active coils per cell" is used. This means that when there are four coils per cell, and a dead coil is used, there will be three active coils per cell in the data coil. The rules for a half-idle bar will be given later.

In the shape of a formula, the above rule becomes $[(\text{lead pitch}) + (\text{active coils per cell} + 1)] \div 2$. For example, consider a four-pole machine with a coil pitch of 1-and-13, or 12, and a lead pitch of 1-and-75, or 74, three coils per cell, 49 slots and 147 bars with no dead coil. With the number of coils per cell odd, coil pitch even and lead pitch even, the center line of the coil will fall on slot *F* and bar *S*. Slot *F* equals $(12+2) \div 2 = 7$. Bar *S* equals $(74+3+1) \div 2 = 78 \div 2 = 39$, and bar *P* then equals 75.

(*Please turn to page 458*)

Rules That Govern Relation of Coil Pitch, Coils per Cell and Lead Pitch in Wave Windings

(1) On four-pole machines, when an odd number of slots is used with an even number of coils per cell, there will always be either a dead coil and one bar less than twice the number of slots, or there will be twice as many bars as slots and a half-idle bar. With an even number of slots and an even number of coils per cell, the above rule will also apply.

(2) With an odd number of slots and an odd number of coils per cell, the resultant number of bars will wind without the use of a dead coil or a half-idle bar.

(3) For six poles, with an odd number of slots and an even number of coils per cell, or with an even number of slots and an odd number of coils per cell, a dead coil or a half-idle bar will have to be used. When the resultant number of bars can be divided by 3 without a remainder, the winding will be progressive. When the number of bars is not divisible by 3, but the —1 sign will reduce the bars to a number divisible by 3 without a remainder, the winding will be retrogressive and will not require a dead coil or half-idle bar to make it wind.

(4) With eight poles, the number of bars plus or minus 1, with or without a dead coil or half-idle bar, divided by 4, should result in a whole number. This is the deciding factor on windings of motors having eight or more poles.

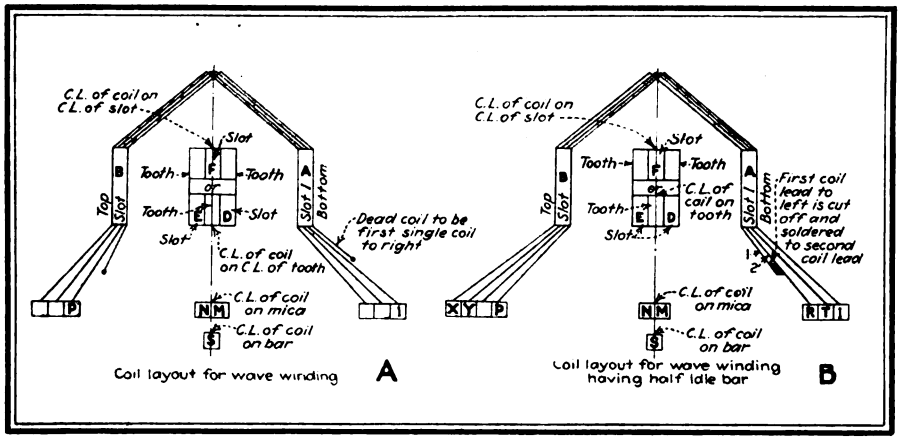


Fig. 3—The location of the commutator, core and coils with respect to each other may be determined from these diagrams, as explained in the text.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, September, 1925

Now Is the Time to Clean Up Outside Work

IT IS a good plan to go over the plant now, while the weather is nice, and see that all outdoor equipment is in good condition for the winter. If metal work such as crane tracks, transformer cases, and the like, is to be painted, it is particularly important that this be done in warm, dry weather, in order that the paint may have an opportunity to dry properly.

Yard circuits, comprising power, telephone, fire alarm and other lines should be inspected to see that the wires are not sagging unduly and that the poles or other supports, insulators and so on are in good shape. Ice or sleet and strong winds put a heavy load on wires and their supports, and trouble may be avoided later by taking care of them now.

It is likewise advisable to go carefully over all water, steam, gas, air and other lines and see that any needed repair work, such as stopping leaks and replacing damaged coverings, is done.

Plant buildings should come in for their share of attention, in the way of replacing cracked or broken window panes or skylights, painting fire escapes and other metal work, pointing up the brickwork, and so on.

Outside installation or maintenance work of any sort can be done now in much greater comfort and just as cheaply, if not more so, than later on.

Do You Have Trouble Getting Rid of Grounds?

THE first manifestation of operating trouble on electrical equipment is usually in the form of a "ground," that is a weakening or failure of some part of the insulation of a conductor.

When one side of the line is grounded it throws an additional potential strain on the other side, which before long will result in a short-circuit with its ensuing damage to equipment and delay to production. A series motor having a grounded field coil will, under certain conditions of overhauling load, generate a voltage considerably in excess of the operating voltage, thus endangering the insulation on all nearby equipment. Consequently, the maintenance force should be constantly watching for grounds and upon their appearance should quickly locate and clear them. The frequency with which grounds occur and the quickness with which they are cleared may be taken as true indices of the operating conditions and character of maintenance observed in the plant.

Some operators occasionally ring out the apparatus with a magneto, and let it go at that. Others use a system of lights connected to the bus; while some use a voltmeter which can be plugged between either line and ground. All of these systems have one fault; they depend upon someone focusing his attention on them at the particular time that a ground appears—no automatic record is taken of the appearance of the ground. Since many grounds come and go, it is indeed quite a coincidence when a ground is discovered on its first appearance.

In an article on page 415 of this issue a graphic ground detector is described, which automatically makes a record of all grounds. A system of using the ground detectors so that responsibility for the location and clearing of grounds is definitely fixed, insures prompt removal of this trouble. R. H. Bahney, author of the article, reports that since he installed this system he has been able to reduce the delays on direct-current equipment by 26 per cent. Surely that is sufficient to warrant the investigation of this subject by everyone responsible for the maintenance of electrical equipment in industrial works.

Let Your Men Assume Some Responsibilities

AN executive who is proud of the smoothly-running organization which he has built up, recently decided to take a vacation, for the first time in several years. In order to make sure that the work of his department would be handled satisfactorily in his absence, he purposely kept away from the plant for a day or two, on several different occasions. The results of this test were both surprising and disappointing to him.

In his endeavor to keep mistakes down as low as possible, he had reserved for himself the right to make practically all decisions and oversee all of the details of the work of his department. As a result, his men were not used to assuming any responsibility. They did not know how, or were afraid, to make decisions. In consequence, when he was not there, the work of the department almost stopped.

Such conditions are harmful from every point of view, in any organization. Even if the work is largely routine in character the executive in charge is kept closer to his work than is either necessary or good for him, and the men under him are not being given the training and opportunity to develop that is theirs by right. A department or plant cannot operate at its highest efficiency unless the men are trained to be resourceful: to assume responsibilities and discharge them.

This is particularly true of operating and maintenance organizations. The men in these organizations may be called upon, without a moment's warning, to handle almost any kind of emergency in which clear thinking and prompt action may be worth thousands

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of dollars. Failures and breakdowns wait for no one, and unless the men have been properly trained to rely on their knowledge and experience and use their own judgment, an apparently efficient organization may, in the absence of the chief, fail miserably just when its services are needed the most.

One of the marks of a good executive is the ability to train men to take responsibility and fit themselves for the jobs higher up. An honest answer to the question, "How well do your men handle their jobs when you are not there to direct them?" may show you where some reforms are needed in your methods of organizing a department.

Covers for Idle Machines Are a Good Investment

IT SEEMS strange that firms will buy expensive machinery and then neglect to take that care of it which could be obtained for a few dollars. This applies particularly to that great class of machines that is operated seasonally or on special orders and then stands idle for a considerable period, collecting dust. All of this foreign matter must be wiped off before the machine can be put in good operating condition again. In case this is not done the moving parts start up under severe friction loads; often injurious matter is ground into the bearings and may cause considerable damage.

Many plant executives go part of the way, although only part, in this matter of protecting machinery. They allow the operators or helpers time to clean up the machine after the last run. Then the machines will be allowed to stand unprotected until the time comes to run them again. That means that they have to be gone over and coaxed into the same running freedom in which they were when stopped. This may often take nearly as much time as did the original cleaning.

If covers are provided for machines, they can be protected as soon as they are cleaned. When needed again, they are instantly available. One print shop in a small town has a five-month period of idleness for their "big press" which cost them over $20,000. This concern has its maintenance so well directed that after a helper spends two days in cleaning this press from its last run, a slip cover is put over it until the next season opens up.

Canvas or muslin or any fairly closely woven cloth will serve as cover material. Various remnants and odd lots of materials, such as surplus government tarpaulins, that will make good covers, often can be bought cheaply. Covers do not need to fit around a machine, although that is an advantage. A substitute for the fitted cover is a single piece large enough to throw over and drape down the sides or, still better, to be tied around with a cord.

Clean machinery has a higher value than dirty; it adds greatly to the appearance and morale of a plant. The cost of protecting equipment and keeping it clean is trifling, and will be more than repaid in lessened depreciation.

Much has been done to popularize "life extension" and yet the same men who are practicing this for themselves sometimes do not think of applying the same policy to valuable machinery in their plant. This is a phase of maintenance that will bear increasing attention, with the returns in direct proportion to it.

Why Burn Lights In the Daytime?

ONLY too often in industrial plants is lighting thought of as something to be seen and not looked after. Many of us know the shortening of life that results when overvoltage is applied to lamps and everyone will agree that clean reflectors will result in more illumination than dirty ones. Clean reflecting units and correct voltage are two things that must be systematically obtained if efficient lighting is desired.

There is another factor, however, that will result in longer lamp life and saving in energy consumed. We refer to the economy of turning out electric lights when not needed. The importance of this is frequently not realized. It is a needless expense which runs up lighting costs considerably in a plant of any size.

In a case recently brought to our attention it was found that 35 per cent of the larger lamps were left burning when not needed. After a little educational work only about 5 per cent of the lamps were left burning in the daytime. This educational work can be confined to telling everyone to turn out lights when not needed or, better, the job can be delegated to certain individuals in each department.

In the case just mentioned the saving was estimated at 1,440 kw.-hr. per day, or an annual saving of $5,400, which was well worth considering.

Test and Maintain Spare Equipment Also

A RECENT incident in a large plant brings home the importance of maintaining the spare equipment as well as the equipment in service.

In this plant one of the drives requires a direct-current motor of several thousand horsepower and since the drive is of the utmost importance to continuous plant operation it was thought advisable to purchase a spare armature for the motor. This was done and the spare armature was covered with paper, placed in the motor room, and left to take care of itself.

One day the regular armature for this motor failed, with a large shower of fireworks. Investigation showed that the best thing to do was to rewind the armature. Inasmuch as the production of the entire plant depended more or less on this one drive, all haste was made in changing the large armatures. All of the men involved congratulated themselves that they had a spare armature to replace the damaged one, for rewinding this large armature was a matter of a week or more. Much to their surprise, however, shortly after the application of power to the motor the spare armature shorted and grounded in several places. So now instead of having one armature to rewind, they have two, and meanwhile the drive is not in production.

This example illustrates only too well the need of maintaining and testing the spare equipment just as carefully as the equipment that is in service. In fact operating conditions in many cases are not so hard on the electrical equipment as standing idle is. Warm motors, such as those in operation, do not collect moisture, while idle, cold machines do. Spare armatures and other electrical equipment having insulation should be cleaned, painted, and tested just as often and just as thoroughly as the regular equipment.

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Twentieth Annual Convention of

Association of Iron and Steel Electrical Engineers

To Be Held in Connection With the Annual Iron and Steel Exposition at Philadelphia, Pa., September 14 to 19, 1925

UNUSUAL efforts have been put forth by President Cummins, Business Manager Kelly and the various committees in charge, to make the 1925 Convention of the Association of Iron and Steel Electrical Engineers, better and more interesting than ever before.

President Cummins of the Association of Iron and Steel Electrical Engineers extends in the accompanying letter a most cordial invitation to the readers of INDUSTRIAL ENGINEER to attend this convention which will be held at the Philadelphia Commercial Museum, Philadelphia, Pa., Sept. 14 to 19, 1925. The annual Iron and Steel Exposition, at which a large number of manufacturers exhibit the latest developments in equipment used in the iron and steel industry, will be held in connection with the convention.

There will be a slight change in the usual order of procedure at this convention. Heretofore it has been the custom to hold the business meeting on Monday. This year the program will start at 12:30 p. m., Monday, in with an informal luncheon, at which time everyone who is attending the convention is expected to be present. This luncheon will be held at the Benjamin Franklin Hotel. Meetings on the other days will be held at the Philadelphia Commercial Museum, which will also house the annual Iron and Steel Exposition.

Technical sessions of the Convention of the Association of Iron and Steel Electrical Engineers are scheduled for Monday, Tuesday, Wednesday, Thursday and Friday, Sept. 14 to 19. The subjects that will be discussed at these sessions are as follows:

MONDAY NOON—SAFETY DIVISION

12:30 p. m.—The first session of the Convention will be devoted to the Safety Division, starting with a luncheon at 12:30 at the Benjamin Franklin Hotel.

1:30 p. m.—Introduction by A. C. Cummins, President, A. I. & S. E. E.

Remarks by L. H. Burnett, Asst. to Pres., Carnegie Steel Co., Pittsburgh, Pa.

Remarks by Henry Renninger, Asst. to Pres., Lehigh Portland Cement Co., Allentown, Pa.

How the Electrical Engineer and the Safety Engineer Can Be Mutually Helpful, by John A. Oartel, Chief of Safety Bureau, Carnegie Steel Co., Pittsburgh, Pa.

TUESDAY MORNING

9:30 a. m.—The Selection and Maintenance of Oil Circuit Breakers, by George A. Burnham, Condit Electrical Mfg. Co., Boston, Mass.

11:00 a. m.—The Selection and Maintenance of Oil Circuit Breakers, by M. J. Wohlgemuth, Switchboard Engr., and E. K. Reed, Circuit Breaker Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

1:00 p. m.—Discussion of papers delivered in the morning session.

WEDNESDAY

9:30 a. m.—Direct Current Armature Windings for Multipolar Generators and Motors—Frog Leg Windings, by W. A. Powell and G. M. Albrecht, Engrg. Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

THURSDAY

9:30 a. m.—Electric Heat Treating Furnace Applications, by E. A. Hurme, Manager Steel Mill Division, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electric Melting Furnaces, by J. A. Seede, Industrial Engr., General Electric Co., Schenectady, N. Y.

Report of Electrically Heated Soaking Pit, in operation at the Donner Steel Co.

FRIDAY

9:30 a. m.—Auxiliaries and Auxiliary Drives for Steam Electric Generating Stations, by A. L. Penniman, Jr., and F. W. Quarles, Consolidated Gas, Electric Light and Power Co. of Baltimore, Baltimore, Md.

11:00 a. m.—Extending the Heat Cycle in Boiler Operation by the Use of Preheated Air for Combustion, by J. G. Worker, Vice-Pres., American Engineering Co., Philadelphia, Pa.

It will be noted that the papers to be given at these sessions cover a number of subjects which are of unusual interest. In addition to the program given above, arrangements have been made for inspection trips to a number of steel plants and large industrial works, including the South Philadelphia Works of the Westinghouse Electric and Manufacturing Co.

Industrial plant men can find no better way to aid in the growth and advancement of their professions than by attending and co-operating in the gatherings of their fellow workers when they meet to discuss the problems that confront them all. Such meetings not only aid in the progress of the profession, but also help those who attend and co-operate to broaden their vision and widen their experience.

In addition, an unusual opportunity is afforded at such meetings to make acquaintances and friends with whom an exchange of experiences and co-operation in the solution of new problems as they come up will be mutually profitable. It does every engineer good to get away from the plant for a while and have an opportunity to meet and hear others express their opinions on problems that are of common interest.

Association of Iron & Steel Electrical Engineers

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Pittsburgh Pa.
September First,
1925.

TO THE READERS

OF INDUSTRIAL ENGINEER.

On behalf of the Board of Directors of the Association of Iron and Steel Electrical Engineers, I am extending to you an invitation to attend our Twentieth Annual Convention and Exposition, to be held at the Philadelphia Commercial Museum, at Philadelphia Pa., September 14th to 19th, 1925.

Our Association's activities for the past nineteen years have been directed solely towards the advancement of the application of Electricity to the Iron and Steel Industry and today, we can safely claim that at least 55% of our Industry has been electrified. Provided the trend of the times is any indication it will require about ten years to completely electrify the Iron and Steel Industry.

Your co-operation and interest is earnestly solicited in joining with us at our Convention, helping us, advising us, better ways, better methods, to bring about complete electrification.

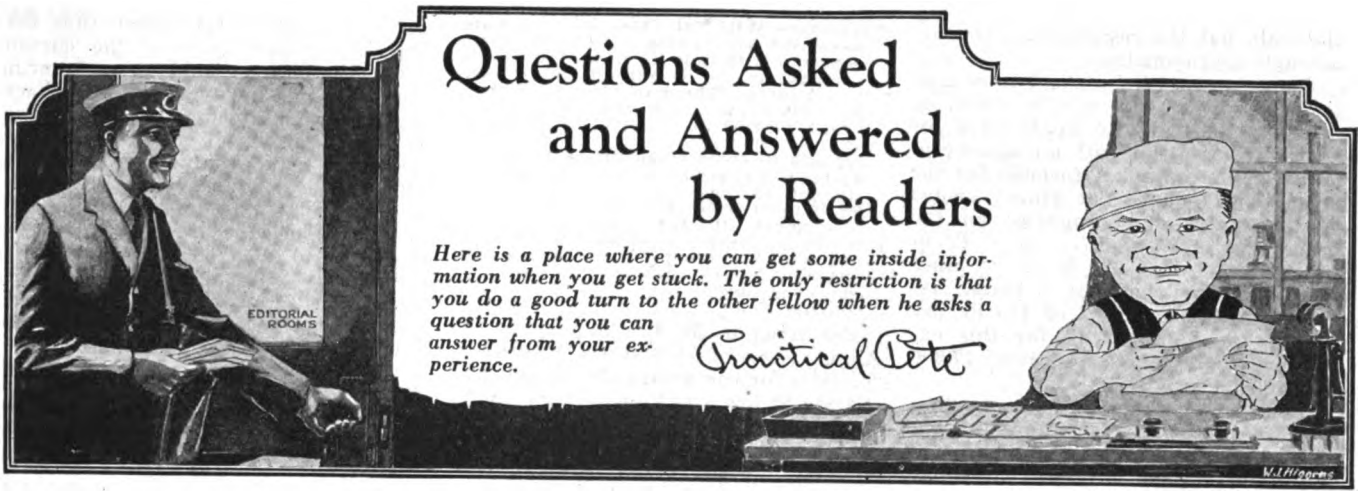
Your assistance will be appreciated and your attendance at our technical sessions will be welcomed. You are also invited to visit our Iron and Steel Exposition, being held at the Philadelphia Commercial Museum.

Assuring you that our membership will be glad to provide for your conveniences and comfort while their guests at their Convention, believe us to be,

Yours very truly,

President.

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Who Can Answer These?

Will Flexible Couplings Reduce Gear Shock on Motors?—I would like to obtain the views of some of our readers on the value of a flexible coupling in preventing the shock and vibration of gears from reaching the motor armature and commutator. We have encountered some trouble from vibration and gear shock affecting commutators and I am wondering if flexible couplings between the motor and the gear drive would help me in eliminating this trouble.
Omaha, Neb. M. P.

* * * *

Simple Device for Winding Small Armatures—I should like to know if any of our readers can tell me how to construct a simple machine that can be made in the shop and used for rewinding small armatures of the fan and vacuum cleaner types. I should also like to know what other equipment is necessary for the rapid handling of this kind of work. Winding these armatures by hand is too tiresome and slow, and we do not have enough of this work to warrant the purchase of an expensive winding machine.
Brooklyn, N. Y. G. A. L.

* * * *

Transformer for Burning Out Grounds in Conduit.—I shall appreciate it if some reader will give me data and directions for making a transformer for burning out grounds in conduit. If there is any choice in the matter I can operate this transformer on either 110 or 440 volts, 60 cycles.
Monroe, Mich. C. J. H.

* * * *

Treating Windows to Prevent Glare.—I would like to obtain the experience of other readers in treating windows to prevent glare from the sun, particularly on western exposures during the late afternoon. At times this is almost unbearable in parts of our shop. What treatments, if any, have other readers found satisfactory; or would it be better to use shades and, if so, what kind?
Des Moines, Iowa. D. J. C.

* * * *

How to Determine Horsepower of a Shaft or Clutch.—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required.

I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m
Grand Rapids, Mich. E. E. H.

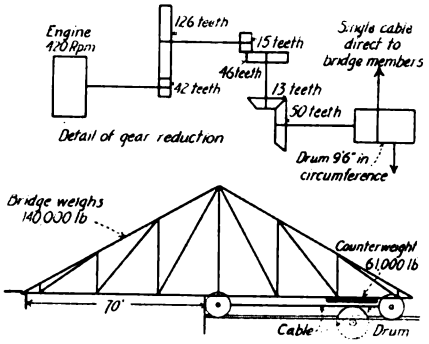
Why Does One Brush Arc on This Commutator?—I have been testing some series-wound motors rated at 1/60 hp. These run 1,600 r.p.m. under load and take about 0.4 amp. Speed is governed by a three-ball friction governor. With the governor released, the speed is 7,000 r.p.m., at no load. The motor is connected in series with 180 ohms resistance across a 110-volt a.c. line, thereby impressing about 38 volts across the armature.

We have considerable trouble with the brushes arcing and cutting the commutator. This makes the speed very irregular; so we are trying to improve the commutation. Offsetting the brushes so that they do not track increases the trouble. One brush will arc badly, while the other does not and leaves a very little carbon deposit on the commutator.

The commutator has 36 segments and is 1¼ in. in diameter. We have used several grades of brushes, but the best lasted only 368 hr. If anyone can explain this trouble or help me improve the commutation, I shall appreciate it.
Camden, N. J. L. G. J.

* * * *

Size of Motor Required to Operate Drawbridge—I wish to know how to determine the size and speed of motor required to operate a drawbridge that is now operated by a steam engine. The diagram shows the general layout of the bridge. It weighs about 140,000 lb. and travels 70 ft. in 45 seconds. It is supported on four steel wheels 30 in. in diameter with a 12-in. face, running on steel rails. The bridge is pulled back and forth by a steel cable running on a drum which is driven by the engine through a gear reduction; this could be changed to a worm gear



if necessary. The speed of the engine is 420 r.p.m. while the drum turns at 10 r.p.m. I do not know the horsepower of the engine, nor is it equipped to take an indicator card, but the following data may help: Duplex engine (both cylinders receive same pressure); steam pressure, 50 lbs. per sq. in.; cylinders 8 in diameter by 10-in. stroke; speed 420 r.p.m.; non-condensing.

It will be necessary to use a two-phase, 60-cycle, 550- or 2,200-volt motor. I shall be very grateful for any help readers can give me.
Quebec, Que., Can. W. S. B.

Answers Received To Questions Asked

Strength of Brick Walls—We can find very little test data on the strength of brick walls with respect to forces acting against the wall horizontally and at right angles to the plane of the wall. If any readers have pulled down old brick walls they may be able to give me some data regarding the force required.

Suppose we have a brick wall three courses thick, 36 ft. high and 60 ft. long, with no openings and supported at each end by being tied to side walls of the same height and thickness. Assume that this wall has been standing for over a year and was constructed of No. 1 red brick and good mortar, well laid, with header courses placed in the standard manner.

What would be the approximate force required to pull this wall down, assuming the force to be applied at a point half-way up the wall and midway between the ends?
Bowmanville, Ont., Can. L. J. C.

In the June issue, L. J. C. expresses a desire to know what force would be required to pull down a brick wall 13 in. thick, 36 ft. high, and 60 ft. long, which is bonded into side walls. The force is to be applied at the middle of its length and height; that is, at its center.

I do not believe that the wall described can be pulled down by a force applied at its center. It seems to me that a portion surrounding the point of application of the force will be pulled out, due to failure of the mortar joints by a combination of shear and tension. And whether the brickwork above the hole will fall will depend on the size of the hole and the corbelling action of the brickwork.

As L. J. C. says, there are little data on the strength of walls subject to such action as he describes. While numerous walls have been pulled down, few men concern themselves with the precise magnitude of the forces involved. There are abundant data concerning the design, and behavior of retaining-walls, which are subject to loading over the whole area (the resultant pressure being assumed to act at one-third of its height, as on dams), but the forces on a retaining-wall differ vastly from those existing in this case. One could, of course, assume strength values of the brickwork in shear and tension, and reach a conclusion that might be a guide to the strength of

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the wall, but the result would be only a rough approximation.

Assuming that a "washer" were used to transfer the pull of the chain, or cable, to the wall, we would have for consideration a slab with a load concentrated at its center. A formula for the strength of square flat plates, loaded at the center and supported on the four edges is $W = .67 \times S \times t^2$; in which W = load in lb., S = fiber stress, and t = thickness of plate. Assuming a "fiber stress" of 150 lb. per sq. in., the value of W for this example is, $0.67 \times 150 \times 13^2 = 17{,}000$ lb., approximately.

I would not presume, however, that the foregoing is within hailing distance of the correct solution. So many unknown factors are involved that a correct solution could not be hoped for. Were the wall free at the ends, and narrow enough to insure its movement as a unit, an approximate solution might be derived from a consideration of the forces producing stability. Even then large errors may arise from ignorance of just at what point above the base the wall will turn over; this point may be, because of varying bond strength of the mortar, anywhere up to about a sixth of the height.

In *The Surveyor*, London, Aug. 20, 1920, there is a report of the Building Research Board, on tests to determine the strength of thin walls loaded on the top and subjected to a horizontal pressure applied at mid-height. The one of interest here was made on a brick wall 4½ in. thick (one course), 3 ft. 6 in. wide, and 8 ft. 6 in. high, laid up in 3 to 1 cement mortar. A vertical load of 1 ton per lin. ft. was applied to the top of the wall with a hydraulic testing machine. The wall was broken by a horizontal load of 895 lb. applied at the middle of its height; the "fiber stress" was 161 lb. per sq. in.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

How Does This Motor Start?—I have a motor made by the General Electric Company that has the following nameplate data: Ser. No. 79,281, type IS, class 4, form A, 60 cycles, 1,800 r.p.m., ½ hp., 110 volts. The nameplate does not say whether the motor is single phase, but as there are only two leads coming out of the machine, I think that it must be a single-phase motor. It has a solid rotor, no starting switch, and no split winding for starting the motor. The winding in the stator is similar to a chain winding. The armature has 36 slots, two of which are empty. The empty slots are spaced seven slots apart. Can some reader tell me how this motor is started from a single-phase power supply?

Oakland, Cal. N. N.

Referring to N. N.'s question in a late issue, the Type IS motor is a single-phase motor which requires a resistance-reactance starter. Such a starter provides the phase-splitting effect necessary for starting the motor. The resistance-reactance is cut out when the motor is brought up to speed. If possible such a motor should always be started light; that is it should be started up disconnected from the load and the load applied after the motor is up to speed. A suitable starter known as the CR-1027 can be obtained from the manufacturer. R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Contactors Will Not Close on Low Voltage.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition? M. P.

Omaha, Neb.

Referring to M. P.'s inquiry in the August issue of INDUSTRIAL ENGINEER, the coils for contactors are designed to operate at low and high voltage limits. Generally, the contactors operate at 10 per cent above and below normal rated voltage, but the per cent varies depending upon the nature of the service and the kind and make of controller. M. P. does not state whether the supply line is a.c. or d.c., although from his account of the trouble it appears to be a.c. On some d.c. controllers where a protecting resistance is cut in, in series with the coil when the contactor closes, a voltage 30 per cent below normal rated voltage will close the contactors. On some a.c. controllers a voltage 20 to 25 per cent below normal rated voltage is used for testout.

If M. P.'s controllers operate on d.c., I suggest that he write to the manufacturer giving complete nameplate data and the lowest voltage at which the equipment is to function. If the supply is a.c. he can improve the functioning of the contactors by decreasing the magnetic gap at the outer pole of the switch and the armature lever by 1/64 to 1/32 in., by preventing the armature lever from dropping back the full amount. This, of course, will proportionately decrease the arc gap which will not be serious considering that the contacts have already been worn down to compensate for the readjustment. Since he does not give any voltage values indicating the variations, it is difficult to state whether he is operating beyond the voltage range; if so, then the problem is to devise some means to keep the voltage more constant. E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Will Shorting Slip Rings Injure Motor?—Will short-circuiting the slip rings on a three-phase, wound-rotor, induction motor damage it? This is likely to happen when the external resistance is entirely cut out of the circuit so as to speed up the motor as much as possible. What takes place when one or more of the brushes do not make contact with the slip rings of such a motor? B. R. B.

Milwaukee, Wis.

Answering B. R. B. in the June issue, he should, it is believed, short circuit the slip rings of his three-phase wound rotor induction motor for normal operation. The resistance in the secondary is usually provided for starting under somewhat of a load and for reduction of speed below normal. With the usual starter the slip rings are short-circuited when the handle is turned to the running position. In places where there is much vibration it may be desirable to install an enclosed switch to short-circuit the rings, after the motor is running at normal speed, thus taking the greater part of the current from the starter and so preventing some possible burning of the contacts due to the chattering which is set up by the vibration. If one of the brushes does not make contact with its slip ring the secondary will run single-phase. That part of the rotor will then be overloaded and may be damaged due to heat. There may also be vibration set up due to the eccentric magnetic pull on the rotor which could damage the bearings and in time the whole machine. D. W. BLAKESLEE.

Electrical Engineer,
Jones and Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Answering B. R. B. in the June issue, shorting the slip rings of a three-phase, wound-rotor motor will not in any way injure the motor; it is in fact the full-speed condition of any motor of this type. It is assumed that in B. R. B.'s case an externally-mounted resistance is used, in which event the rings are short-circuited in the controller. Should one or more brushes not make contact, the effect will be noticed in the supply circuit by the unbalancing of the current, and is comparable to the behavior of a motor having resistances of different values in the rotor circuits.

C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
New York, N. Y.

* * * *

Replying to B. R. B. in the June issue, it is not unusual to have a three-pole, single-throw switch mounted on the motor with one side of the switch tapped on at the brush holders and the other side shorted with a suitable piece of copper. When the machine is up to speed the switch is closed and cuts out the external resistance.

If one brush does not make contact with the slip ring the speed will be reduced and in time the motor will heat. If the brushes on two rings do not make contact the motor will stop, as there will be an open circuit in the rotor and consequently no inductive action between the stator and rotor windings.

San Diego, Calif. E. A. FINLEY.

* * * *

In reply to B. R. B.'s question in the June issue, he should experience no trouble in cutting out all of the secondary resistance in a wound-rotor motor, as most of them are designed to operate that way. The resistance is oftentimes used only during starting and when the last point on the controller is reached the motor runs as an induction motor and develops its maximum horsepower. It would not do, however, to discard the grid resistance and permanently short-circuit the rings as, for one thing, the resistance of the rotor would be too low and the motor would not have enough starting torque to start under any appreciable load.

If none of the brushes on one ring is making contact the motor will run at approximately half speed. If one or more brushes do not make contact the effect will depend on the number of brushes there are on each ring; the more brushes there are, the less will be

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the effect of dropping out one or more. On small motors where there are, say, only two brushes to a ring, the effect will be more pronounced. In general the effect will be practically the same as though there were a high-resistance rotor in the motor. The slip will be greater than the motor was designed for, with a consequent reduction in horsepower. The remaining brush or brushes will have to carry more than their intended current and will heat more, which will make matters still worse.

It is well to watch the slip rings to see that they run fairly true. If they are badly pitted or have an uneven surface they are likely to cause poor operation, on a fairly high-speed machine.

NICHOLAS J. WEISS.
West New York, N. J.

* * * *

Referring to B. R. B. in the June issue, short-circuiting the slip rings of a three-phase, wound-rotor motor will not damage it, as this operation will cause the motor to run as a three-phase, squirrel-cage induction motor. In fact, it is possible to short-circuit permanently the slip rings of a wound-rotor motor and operate it as a straight induction motor, with only a slight loss in efficiency, by means of an ordinary compensator. This may easily be done in emergencies.

When one or more brushes fail to make contact with the slip rings the motor may start with a slow jerking motion, or may fail to turn over and emit a loud, humming noise.

Riverside, Calif. PHIL D. COMER.

* * * *

Referring to B. R. B.'s question in the June issue, no harm can be done by short-circuiting the rings of this motor, as that is the normal running condition. The rings are always shorted through the external resistance, the purpose of which is to cut down the line current drawn and improve the torque at starting, as a higher resistance has that effect.

The external resistance is cut out step-by-step by the controller and an examination of any wiring diagram pertaining to this type of motor will clearly show the short-circuited condition on the last controller point.

If one or more sets of brushes do not make contact, the motor usually will not start or, if it is running, it will roar, overheat very quickly and stall.

The writer has a number of these motors to maintain and usually short-circuits the brushes of a repaired motor, thus enabling it to be started by a compensator in place of a drum-type controller, in the repair shop.

Chief Electrician, JOHN F. BYERS.
Libby Owens Sheet Glass Co.,
Charleston, W. Va.

* * * *

In answer to B. R. B.'s question in the June issue, the motors he mentions are built to run at maximum speed and efficiency with the rotor short-circuited and there is no danger of damage. When the rings are short-circuited these motors have practically the same characteristics as a squirrel-cage motor. In case the resistor and controller become damaged these motors may be short-circuited at the rings and started by the use of a standard compensator of sufficient capacity, although they will not develop very much starting torque when operated in this manner.

If a brush is lifted from a ring while the motor is running the rotor circuit will be opened unless there is a short-circuiting device on the shaft beyond the rings. Opening the rotor circuit will cause the motor to operate single-phase and only one-third of the coils will be active. The rotor will heat badly under these conditions and if run for any length of time the soldered joints would probably come loose and make it necessary to resolder the connections.

Practically all wound rotors of the polyphase type have three-phase windings, regardless of whether it is a two- or three-phase machine, and for this reason care must be taken to see that all of the brushes are doing their work, or the machine will overheat. I have had experience with a great many old, wound-rotor motors using a drum controller for cutting out the resistance. Many of these controllers have insufficient copper contact surface, which resulted in burned out-controllers and damaged rotors. To overcome this difficulty a switch was installed to increase the capacity of the short-circuiting device.

After the controller was put on the last point the switch was closed and made a solid tie across the rotor. Of course, this could not be done with a variable-speed motor, such as B. R. B. is evidently operating, but the brush question is very important and rings and brushes must be kept in first-class condition on wound-rotor motors.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In the June issue, B. R. B. asks about short-circuiting the slip rings of a wound-rotor motor. This will not injure it.

When one or more of the brushes do not make contact with the slip rings the resistance of the secondary circuit will be increased, the speed will be decreased and the remaining brushes will have to carry more than normal current per square inch of surface. If none of the brushes on one ring make contact, leaving a single-phase rotor, the torque will be about 60 per cent of normal, the secondary current in each case being the same. If the brushes on two rings fail to make contact the motor is likely to be damaged, unless it is equipped with protective devices.

Hopewell, Va. R. M. BUSH.

* * * *

Replying to B. R. B. in the June issue, a short-circuit on the rings of a slip ring motor will cause no damage, as that is the normal running condition at full speed, even though the short-circuited condition is brought about through the controller. When the resistance is entirely cut out of the circuit the motor practically becomes a straight induction motor and will come up almost to synchromous speed.

When one set of brushes, that is all of the brushes acting on one ring, do not make contact the motor will operate at about half speed and if an attempt is made to carry full load the windings connected to the working rings are likely to be burned out. When two rings are rendered inoperative because the brushes do not make contact, the motor will stop and no damage will be done, as the stator current will drop to the small amount required for magnetizing current only.

Seattle, Wash. W. MONTELIUS PRICE.

* * * *

Connecting Lineshaft Directly to Motor—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.

St. Louis, Mo. B. G. S.

In answer to B. G. S.'s question in a late issue, it is my opinion that it would be very difficult to make such an installation give satisfactory service. Driving a lineshaft at 870 r.p.m. would in all probability cause the supports to vibrate considerably and it would, therefore, be hard to support them solidly. Unless the machines driven are of unusual character, the pulleys would have to be rather small, which might allow the belts to slip.

If the motor must be connected directly to the lineshaft the supports for the latter should be firmly anchored to the ceiling and either roller or ball bearings used.

Vibration can sometimes be lessened by placing the driven machines on both sides of the lineshaft, so that the belts also pull from each side.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

Replying to B. G. S. in a recent issue I would not, for various reasons, consider it to be the best of engineering practice to undertake such an installation as mentioned. However, if this is the only way of getting power in the place desired, I would advise mounting the lineshaft on top of concrete pedestals which I would place about 8 ft. apart.

Also, on the lineshaft I would place three small flywheels, spaced equidistant between the motor and the driven machine. The flywheels need not be large, as their purpose would be to prevent whipping of the shaft, rather than storage of power, although this latter effect might be helpful.

I would advise the use of high-speed, sleeve bearings, in order to cut down the expense. A bearing composed of 16-20 parts tin, 2 parts antimony, 1 part lead, and 80 parts copper, should give good service. The bearings should be well lubricated.

Extreme care must be exercised in balancing and aligning this shaft in order to secure the best results.

West Allis, Wis. EDWARD JAMES.

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How to Use Megger for Testing Insulation of Motors—I wish some reader would give me a few suggestions on the proper method of using a megger for testing the insulation resistance of motors. I should also like to know what is considered a satisfactory reading when testing 110/550 volt, a. c. and d. c. motors ranging from 5 hp. to 50 hp.
Latrobe, Pa. J. K. W.

Answering J. K. W. in a recent issue, the best insructions for using a specialized instrument such as the megger are those issued by the manufacturer. Assuming that J. K. W. does not have any printed directions on the use of this instrument, the following extracts from James G. Biddle's catalog may be of service to him:

(a) To use the megger testing set, place it on a firm and fairly level base and without connections of any sort to the terminals, turn the crank in a right-hand direction at about 120 r.p.m. The pointer should promptly move up the scale and stand over the infinity mark.

(b) Short-circuit or place a low resistance between the earth and line terminals. When the crank is turned the pointer should promptly move down the scale to zero.

(c) Connect the testing leads to the earth and line terminals. If the leads are held in the hand or touch anything and, while turning the crank the pointer indicates less than infinity, there is a leak somewhere which must be removed, before proceeding with the test. If there is no leak between the leads, you may proceed to test the equipment.

(d) Connect the leads to the apparatus to be tested and turn the handle of the megger at the proper speed. While turning observe the position of the pointer on the scale; the reading indicates the value of the resistance under test.

When testing motors that have just been installed, connect the line terminal of the megger to a lead, the commutator or an exposed conductor of the machine, and the earth terminal to the shaft or some bright part of the frame. Test the insulation resistance. On a cold machine this should be at least 1 to 5 megohms. The lower value applies to large machines. Be sure when making the test that all circuits are properly connected. If all of the circuits are not connected together, as in the case of a separately-excited generator, test each circuit or group of circuits separately.

When testing motors in service, the procedure is the same as for a new installation. When a motor is warmed up the insulation resistance will be lower than when cold. For testing 110- and 220-volt apparatus, particularly if it is old, it is best not to use a megger generating over 500 volts unless the insulation resistance has been proven to be quite high. It must also be remembered that when making megger tests the equipment under test must not be live.

The standards of the American Institute of Electrical Engineers require that the insulation resistance of a machine at its operating temperature shall not be less than given by the following formula: Insulation resistance in megohms=voltage at terminals÷(rating in kva. plus 1,000).

This formula applies only to dry apparatus, not oil-immersed.

In the case of a 50-hp., 550-volt motor, this equation would be written: Insulation resistance in megohms=550 ÷50+1,000=0.5 megohms, approximately. In this example I used the rating of the motor in horsepower instead of the rating in kva., but the error introduced thereby can be considered negligible for most purposes.
Fort Worden, Wash. E. I. PEASE.

* * * *

Referring to J. K. W.'s question in a late issue, a constant pressure megger is suggested on account of the electrostatic capacity from the winding to the machine frame. For all machines of moderate size, a megger reading up to 100 megohms will cover requirements.

When holding the megger leads while taking readings, great care must be exercised not to let a leak through the tester give a false reading.

Moderate-sized machines generally show an insulation resistance somewhere between 5 and 50 megohms when cold, but the readings will be much less when the machine has just been taken out of service and is still warm.

After connecting the line terminals of the megger to the collector ring, brush, commutator, terminal of armature winding or field, and the ground terminal to the frame of the machine, the insulation resistance reading is obtained by turning the handle of the megger generator. However, the insulation resistance to ground of a number of connected parts of a machine will be far less than that of the parts taken individually. Likewise, changes in temperature and weather conditions will cause a considerable change in the readings obtained.
New York, N. Y. WM. GLAMEYER.

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With reference to J. K. W.'s question in a recent issue, the use of a megger for testing the insulation of motors should be attended with caution and the judgment gained through practical experience. The megger is not infallible; that is, a high reading will not necessarily indicate that the windings are in absolutely safe condition. In the case of low-voltage equipment there may actually be in the winding exposed copper or bare spots which may be in such close proximity that although a test under certain conditions would indicate everything to be satisfactory, trouble will develop later on due to temperature changes, causing a gradual shifting or change in the windings. In general, a megger test should be considered as more or less of a qualitative test.

In the standardization rules of the A. I. E. E., the following statements are made:

"The insulation resistance of a machine at its operating temperature shall be not less than that given by the following formula: Insulation resistance in megohms=voltage at terminals÷rating in kva.+1,000."

For example, based on this formula the insulation resistance of a 50-hp., a. c., 550-volt motor would be, using 1 hp. as equivalent to 1 kva.; 550÷50 +1,000=0.523 megohms, or 523,000 ohms.

For safety, d. c. motors should be considered on the basis of 1 kva. per horsepower.

It is further stated in the A. I. E. E. rule that, "the insulation resistance is of doubtful significance as compared with the dielectric strength. It is subject to wide variation with temperature, humidity and cleanliness of the parts. When the insulation resistance falls below prescribed values it can, in most cases of good design and where no defect exists, be brought up to the required standard by cleaning and drying the machine. The insulation resistance, therefore, may afford a useful indication as to whether the machine is in suitable condition for application of the dielectric test."

The foregoing quotations from the A. I. E. E. rules state the case of the sphere of the megger very fully. The dielectric test, of course, refers to a test at a higher voltage. For all a. c. motors, this should usually be twice the normal operating voltage plus 1,000 volts. In the case of a 550-volt a. c. motor, 2,100 volts would be applied on this basis, but it is not uncommon to find 2,500-volts used for this purpose. There are also various modifications of these tests.

In conclusion, it may be said that care and good judgment should be exercised in interpreting the results of a megger test.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
New York, N. Y.

* * * *

Regarding J. K. W.'s question in a late issue, for d. c. armatures and fields when the megger shows a reading of three-fourths to one megohm, the armature should be removed, placed in an oven and baked at 95 to 105 deg. C. for 6 to 14 hr., depending upon the size. Then another test should be taken with the megger, while the armature is still *hot;* if this reading is one and one-fourth megohms, or more, dip the armature while hot in a good baking varnish, and allow it to remain under the varnish until the air bubbles stop coming to the surface. When dipping armatures, keep the commutator up and out of the varnish.

When the armature is too large to dip shaft up, make a shallow pan to hold the varnish, deep enough to allow the varnish to reach below the slots. Then place the pan under the armature, which should be placed between two supports, block up the pan to give the proper depth of varnish and revolve the armature, allowing a portion to soak.

After dipping, bake for 6 to 18 hr. at 95 to 105 deg. C. For the best results use a long, low-heat bake. Also, when a large armature has been dipped in a horizontal position, turn the armature 180 deg. after half the total baking time has elapsed.

Before baking the armature for the first time, clean all oil, grease and dirt, etc., off the windings and front V-rings, paying careful attention to the spaces between the core and coil ends. Use

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a soft-hair, bottle-washing brush to clean these parts.

It has been found that a clean and dry winding that shows at least one and one-fourth megohms will stand twice its rated line voltage for a high-potential test to ground, for one minute. Therefore, when an armature after cleaning and baking shows at least one and one-fourth megohms it is worth dipping and baking, and if this process is properly carried out the megger reading and the life of the motor will be greatly increased.

On the other hand, if the insulation is aged or damaged, the readings after cleaning and baking will not be much higher; in fact, in some cases the heat will cause a lower reading. When a lower reading or a reading under one megohm is obtained, after cleaning and baking, it is best to rewind the armature completely—*don't patch.*

After a little experience a man can soon learn to judge whether a motor is worth cleaning and baking by the appearance and condition of the windings.

It is good policy to test every new piece of apparatus when installed and record the megohm readings on a motor card; then take readings every three months and when the readings get down to one megohm or take a sudden drop, investigate at once, for trouble, dirt and oil, etc., will run the readings down. It is surprising what cleaning and baking and dipping will do towards keeping a motor out of the rewind class.

In the case of d. c. armatures that work in oily places, or with bearings that leak oil, the condition of the mica between commutator bars should be taken into consideration when contemplating cleaning and baking. In some cases, when the mica is not too soggy, baking for a long time at low heat, 95 deg. C, will put the commutator into satisfactory condition and make the remainder of the process worth while.

Wilkinsburg, Pa. A. C. ROE.

* * * *

When Should an Armature Be Scrapped Instead of Repaired?—I shall appreciate it if readers will give me their opinion on the following: If an armature needs new coils, a new commutator and a new shaft, especially if it is of the type that has the laminations stacked on the shaft, is a repair job, with only the laminations for a base, a profitable undertaking? Also, when should the core be junked and new laminations used?

Chicago, Ill. J. E. K.

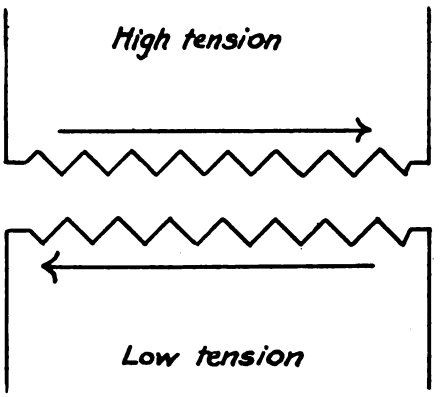
Answering J. E. K. in a late issue, this is a question that can be best settled by consultation with the manufacturer of that particular motor. If the laminations can be removed from the shaft without tearing them to pieces they can be used again, but even under these circumstances they should be treated, annealed and varnished, which is often done to the iron in stators. Under the present-day methods of treating and handling the iron the junking of cores is not so necessary as heretofore. Continual heating of ordinary iron reduces its permeability and increases the hysteresis loss; while silicon steel has non-aging properties that are not affected by heat, ordinary iron can be improved by annealing and varnishing it.

Junking of cores would, then, be considered in the case of iron that was really damaged beyond redemption, or when there was a question as to the feasibility of installing a new armature rather than repairing and replacing the old one. This would be determined by the manufacturer's price for a new core, as compared with the cost of repairing the old one.

West Allis, Wis. EDWARD JAMES.

* * * *

Polarity of Transformer—After reading the article on "Checking and Testing Transformer Connections" on page 560 of the December, 1924, issue of INDUSTRIAL ENGINEER, I am somewhat confused as to the relationship between the primary and secondary voltages for transformers of different polarities. Assume a transformer having primary and secondary voltages in the winding as shown by the arrows in the diagram. Can some reader tell me whether this transformer has additive or subtractive polarity, and why?



Chicago, Ill. G. A. V.

As to the question asked by G. A. V., if the diagram indicates the relative location of outside terminals and if the arrows indicate the induced voltages, the polarity is additive.

In many discussions, I have noted that impressed voltage is considered in one winding and induced voltage in the other winding. This leads to unnecessary complications. If all discussion is limited to induced voltages and arrows indicate only induced voltages, then practically all difficulties connected with polarity problems will be avoided. A. BOYAJIAN.

Transformer Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

* * * *

In reply to the question asked by G. A. V. in a recent issue, the transformer in his diagram has additive polarity. The arrows are taken as representing the instantaneous direction of current flow for one half-cycle. In the next half-cycle the direction of current flow in both windings is reversed. The primary current of any transformer induces a flux in the coil of the transformer that lags behind the impressed electromotive force by 90 deg. This flux, in turn, induces a current to flow in the secondary winding that is 90 deg. behind the flux. Therefore, the secondary current lags behind the primary current by 180 deg., or is opposite in phase.

Whether a transformer has additive polarity or not depends upon how the secondary leads are brought out from the winding; in other words, which lead is considered as being the start of the secondary winding. This may also be influenced by the direction in which the secondary winding is wound around the core, relative to that of the primary winding. To have additive polarity, the external wires bear the same relation to the internal windings as shown in your sketch.

F. ELLIOTT WALDRON.

Gloucester Electric Co.,
Gloucester, Mass.

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With reference to the question asked by G. A. V. in a recent issue, I would say that the marking shown on the sketch accompanying the question is not definite in that we do not know whether the marking indicates the direction in which the windings are wound on the core or the direction in which the currents flow in the winding. If the marking indicates direction of winding, then the transformer is of additive polarity. If it indicates the relative direction of primary and secondary currents, then the transformer is of subtractive polarity.

L. C. NICHOLS.

Engineer in Charge of Transformer Design,
Allis-Chalmers Mfg. Company,
Milwaukee, Wis.

* * * *

Replying to G. A. V.'s question in a late issue, I will say that this transformer has subtractive polarity. It is understood that the arrow shown over the high-tension winding represents the direction of the impressed voltage, while that under the low-tension winding shows the relative direction of the induced voltage, as far as instantaneous values are concerned.

Suppose the transformer in question to be a standard lighting transformer stepping down from 2,200 volts to 220 volts. Let us connect the 2,200-volt side to a 220-volt supply so we can use a plain voltmeter with safety. Since the ratio of transformation is 10 to 1, we would measure 22 volts on the secondary side of the transformer. If we face the secondary side and connect the left-hand primary lead with the left-hand secondary lead and then connect our voltmeter between the remaining primary and secondary leads, we would get a voltmeter indication lower than 220 volts and equal to 220 —22=198 volts, because the voltage induced in the secondary winding is opposed to the normal 220 volts in sending current through the voltmeter. The secondary coil can be considered as a continuance of one leg of the voltmeter to one side of the 220-volt supply, while the other leg goes direct to this supply.

A few years ago, transformer leads were brought out through the tank at random so that even with those of the same make one could not rest assured of the relative polarity without making tests, these tests being always necessary when paralleling transformers of different makes. Nowadays, manufacturers have adopted standard methods in marking the relative high- and

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low-tension leads so that transformer paralleling is made easy. These methods are very commendable and can be appreciated by anyone having to connect transformers as boosters or buckers and also when connecting various kinds of meters to potential and current transformers in various circuits.

HENRY MULFORD.
Patchogue Electric Light Co.,
Patchogue, N. Y.

* * * *

In answer to the question asked by G. A. V. in a recent issue, I would say that this transformer has additive polarity for the reason that the currents in the left-hand, high-tension and left-hand, low-tension leads are flowing in the same direction. Therefore, the potential strain between these two terminals is the sum of the voltages in each winding.

If the transformer were of subtractive polarity, the potential arrows in the winding would point in the same direction while those in the left-hand, high-tension and low-tension leads would point in opposite directions. Then the potential difference between these two leads would be the difference between the voltages in the two windings.

This is not a technical explanation, but I believe it may be clearer than one that is technical.

L. F. GOSS.
Chief Engineer,
Kuhlman Electric Co.,
Bay City, Mich.

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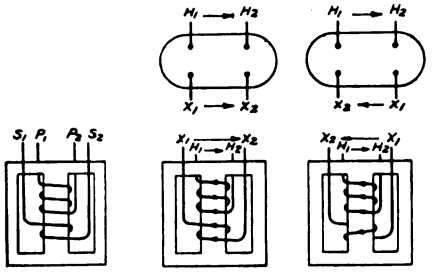
In reply to the question asked by G. A. V. in a recent issue, the transformer in question is of additive polarity. In Vol. 23, No. 5 of the *General Electric Review*, A. Boyajian gives a very thorough discussion of this question. I will try to prove my answer to G. A. V.'s question with an abstract of Mr. Boyajian's discussion.

In Fig. 1 of the accompanying diagram is represented a simple, single-phase transformer. It is of interest to consider the relative direction of the windings and voltages. It will be observed that coil S_1S_2 is wound in the same direction as P_1P_2, assuming that the first coil starts from the S_1 and the second from the P_1 leads. On the other hand, the S_1S_2 coil is wound in the opposite direction to P_1P_2, if we assume that the first starts from S_1 and the second from P_2. We conclude, then, that whether two coils are to be considered as wound in the same direction, or in opposite directions, depends on which terminals are considered as the start and which the finish. Thus, in Fig. 1, coils S_1S_2 and P_1P_2 are in the same direction, while coils S_1S_2 and P_2P_1 are in opposite directions.

Since the primary and secondary induced voltages are induced by the same flux, they must be in the same direction in each turn as is shown in Figs. 2 and 3.

However, whether they will appear in the same or opposite direction as viewed from the terminals depends on the relative directions of the windings. Thus, in Fig. 2 voltages H_1H_2 and X_1X_2 are in the same direction and in Fig. 3 voltages H_1H_2 and X_2X_1 have opposite directions. Also, in Fig. 2, voltages H_1H_2 and X_2X_1 are in the opposite directions and in Fig. 3 voltages H_1H_2 and X_1X_2 are in the same direction.

When the induced voltages of the high- and low-voltage sides are in opposite directions as in Fig. 3, the polarity is said to be additive; and when the induced voltages are in the same direction as shown in Fig. 2, the polarity is said to be subtractive. The reason for this nomenclature will be evident from the following :



Figs. 1, 2 and 3—The voltages induced in the individual turns of the primary and secondary windings are in phase, even though the windings are wound in opposite directions.

Referring to Fig. 2, if we connect a high-voltage lead to the adjacent low-voltage lead, for instance H_2 to X_2, and excite the transformer on either side, the voltage across the leads, H_1 to X_1 will be the difference between the voltages of the two sides. Following the voltage from X_1 to X_2, thence to H_2 and then to H_1 it is evident that the voltage H_2H_1 will oppose the voltage X_1X_2, and the polarity is subtractive.

Referring to Fig. 3, which shows primary and secondary induced voltages in opposite directions, if we connect an H lead to the adjacent X lead, for instance, H_1 to X_2 and excite the transformer, the voltage across the other leads, that is, H_2 to X_1 will be the sum of the primary and secondary voltages, for reasons explained in the previous paragraphs. Hence, the polarity is additive.

Engineering Dept., FRED W. PAFFEN.
American Cellulose & Chemical Mfg. Co.,
Cumberland, Md.

* * * *

In answering G. A. V.'s question in a recent issue, it is assumed that the direction of arrows is given for the voltage impressed on the primary and the induced voltage received at the secondary terminals. In this event, the transformer is described as having subtractive polarity. However, if we are considering the arrows as indicating the direction of induced voltage in primary as well as in secondary, then the polarity is additive.

Since induced and applied voltages are in direct phase opposition, it is apparent in speaking of voltages that it is necessary to specify whether impressed or induced voltages are being considered.

It is undesirable to consider the impressed voltage in the primary and the induced voltage in the secondary, since it is not always certain which is primary and which secondary and, furthermore, polarity and phase rotation are independent of which winding is primary and which secondary. It is the simplest, clearest, and most logical procedure, therefore, to consider only the induced voltage relation.

Since the primary and secondary induced voltages are induced by the same flux, they must be in the same direction in each turn. Whether they will appear in the same or opposite directions as viewed from the terminals, depends upon the relative directions of the windings. When the windings are similarly wound, the resultant polarity is subtractive. The reverse condition, with the windings wound in opposite directions, gives rise to additive polarity.

Schenectady, N. Y. CECIL H. GREEN.

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With reference to the question asked by G. A. V. in a recent issue, the sketch in question shows the transformer as having additive polarity. The arrows indicate relative induced voltage in primary and secondary. With the arrows indicating these voltages they will combine in the same manner as vectors; that is, if one vector begins at the terminus of another vector, then the magnitude from the beginning of the first vector to the terminus of the second, would be the sum of the two. The vectors are obviously combined in this manner in the sketch referred to, when two terminals at the same end of the transformer are connected together, (that is, the terminus of one vector is connected to the beginning of the second vector) and the voltage between the other ends of the windings then would be the difference between the beginning of the first vector and the terminus of the second which is obviously the sum of the two. As pointed out in the article in the December issue of INDUSTRIAL ENGINEER, and particularly in Fig. 2 of that article, when the voltages of the two windings add, the transformer is considered to have additive polarity.

J. F. PETERS.
Transformer Engineering Dept.,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

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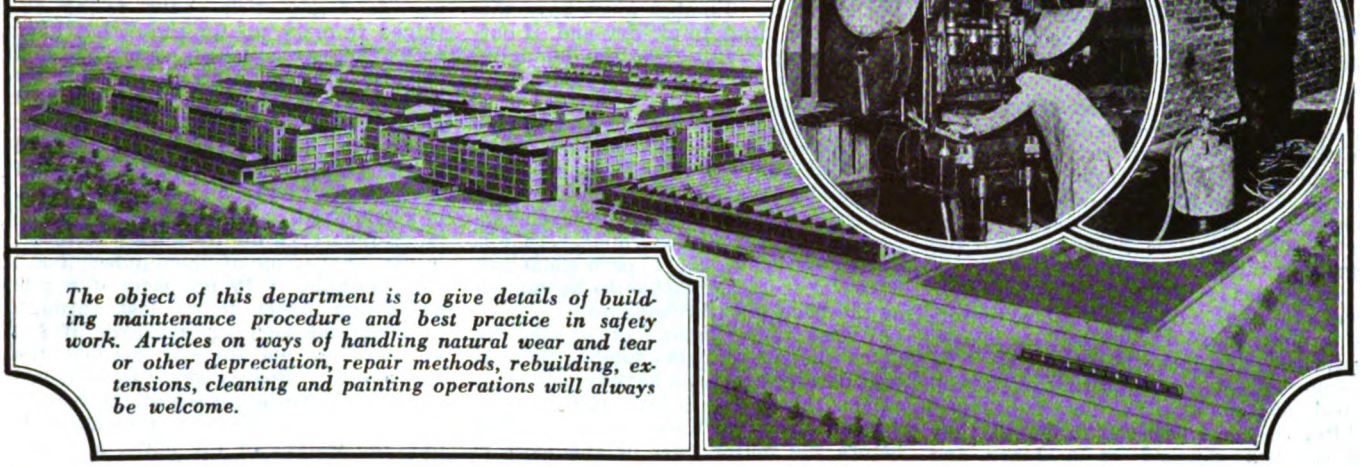
Referring to the question asked by G. A. V. in a recent issue, in which a diagram of a transformer with arrows pointing in opposite directions on the high- and low-voltage sides is shown, the transformer may be taken as having additive polarity. These arrows, however, are sometimes misinterpreted.

The flux in the core of the transformer induces both the high- and low-tension induced voltages. Because of this fact these two voltages must be in the same direction in each individual turn of both windings. If the windings are wound in such a manner relative to each other, or the leads are brought out in such order that the direction of the induced voltages at the leads of both windings is the same, the polarity is subtractive. If the induced voltages are in opposite directions, the polarity is additive. It should be remembered, however, that the induced voltage on the secondary side of the transformer is in the opposite direction to the impressed voltage from the line or generator.

New Orleans, La. OVIDE C. HARRIS.

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Building Maintenance and Plant Safety

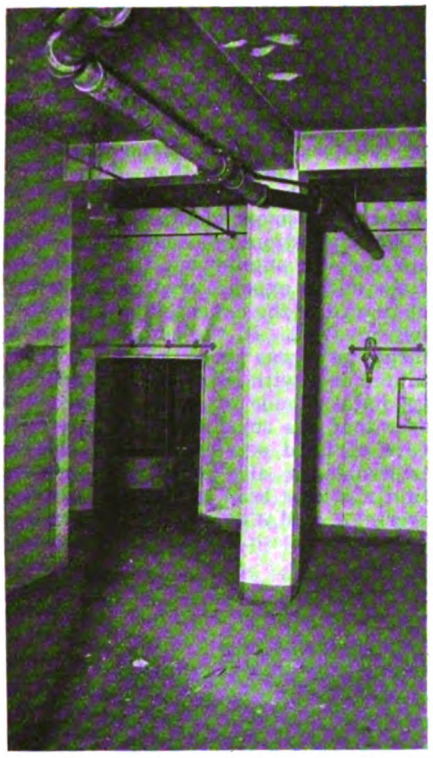


The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Shoring Up Ceiling as Safeguard When Cutting Holes

ONE of the important jobs of millwrighting in any industrial plant is the erection of motors, countershafts and other equipment on the ceiling. A common method of doing this, particularly for heavy pieces, is to drill a hole through the concrete ceiling from the floor above, countersink for the washers used under the bolt heads in the floor and patch them over. In cutting down through the floor with either a chisel or an air hammer, the ceiling of the room below is likely to chip or break out unless it is shored up from below. This is usually done by placing a short plank against the ceiling and holding it up with an upright wedged tightly in place. Frequently the upright alone is used and the hole is drilled down into the end of the upright. In addition to protecting the appearance of the ceiling, this shoring also prevents any large pieces of concrete from falling and injuring anyone who might be passing underneath.

In one plant, where considerable effort has been made toward safeguarding the workers and to teaching all employees to be careful, a photograph was taken showing the result when the shoring was neglected. This photograph was posted on the bulletin board with a notation telling that pieces weighing three to four pounds had fallen from the ceiling and might have seriously injured anyone who happened to be passing. This was followed by a reminder that such accident hazards could be prevented by shoring underneath.



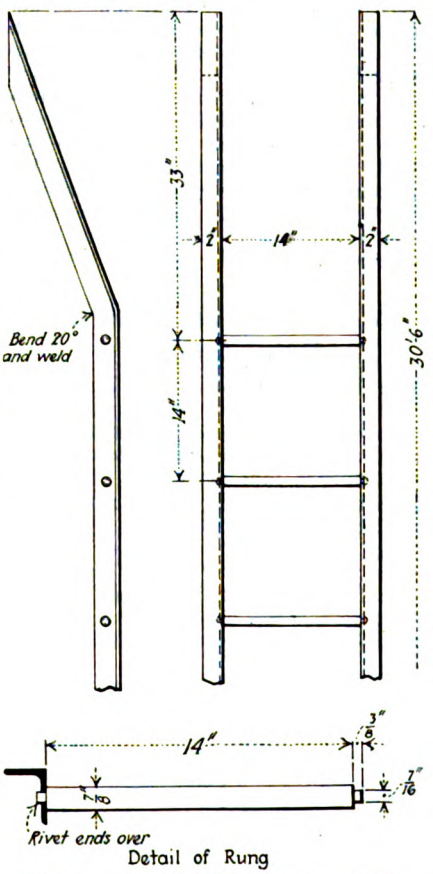
In drilling through from the floor above large pieces of concrete were knocked from the ceiling.

This is not necessary when drilling holes in the ceiling for erecting motors or other equipment. Shoring up from underneath will not only prevent concrete from breaking out around the hole in the ceiling but will also eliminate any possibility of accident to those who may be passing below.

Substantial Metal Ladder for Industrial Uses

IT IS surprising how often designers who are not familiar with the operating side of industry leave out some features essential to operation. One example of this was in connection with several outdoor transformer stations. When ready for use it was discovered that there was no way to get to the several levels of the structures except by the wooden ladders which had been used in construction. It was found that ladders had not appeared in the original specifications. As the contractors had received their final O. K.'s, and moved away, it was necessary to provide ladders, which were made as shown in the accompanying illustration.

The vertical distance to be covered was about 30 ft. Rungs were not required at the top, but the sides had to pitch inward at the top, as shown in the sketch, to a fastening and also to allow clearance for a man's body from an iron walk, or grille, to the ladder.



Detail of Rung

This type of ladder may be easily built and installed.

Where it is necessary to erect ladders around outdoor transformers or machinery this form of angle-iron construction may be built in almost any shop. The strength of this form of construction and the ease with which it may be adapted to any structure and installed, make it useful around industrial plants.

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The sides of the ladders were made of 2½-in. by 2-in. angle irons which were set with the short leg facing the climber. As only 20-ft. lengths of angle iron were available the ends of two pieces were butted and welded. These welded spots were staggered, so that on one leg the weld was 10 ft. from the bottom and 20 ft. on the other. This gave the full length required and also made a neat, smooth job without splicing.

At the top, where the slant came, welding was again resorted to. A V-shaped piece was cut out of the 2½-in. leg, but not through the 2-in. leg. The angles were then bent cold by hand and held at the correct angle, while the cuts were closed up with the welding torch.

The holes in the angles for the rungs were laid out on 14-in. centers, center-punched and the 15/32-in. holes punched on a large punch press. The rungs were made from pieces of mild steel, as shown in the detail drawing. After they had been cut to length, they were then chucked on a Jones and Laughlin turret lathe and a shoulder turned on each end. The rungs were inserted, one side at a time, and cold riveted with a peen hammer.

It is common practice to make ladders used around public service installations and machinery out of two steel flats and with rungs similar to those shown here. However, the ladders described are superior to the others both as to cost and stiffness. To get equal strength in all directions, the ladder with flats for sides would be considerably heavier. The ladders described are as cheap to make as any and are unusually rigid, easy to climb, and capable of bearing any vertical loads likely to be placed upon them. Also, their shape makes them easy to fasten to any steel framework.

Construction of a Crib for Piling Lumber

ALTOGETHER too often, lumber in storage is piled by the hit-and-miss method on a so-called crib, which may consist of four large stones with some timbers laid across it. In some plants the practice is to construct rails of old ties and pieces of old planking, laying the poorest of these on the ground, and pile the lumber on them. A bad feature of piling on such a foundation is the nearness to the ground. The pile also lacks stability when erected on such a foundation. When a pile of lumber is placed on such a makeshift foundation the air does not circulate around the lower tiers.

The prevalent idea is that the main thing to do in piling lumber is to "stick" it; that is, to place cross-sticks between every layer or two so that air can circulate. Lumber must have this circulation of air to air-dry and, if outside, to keep it free from the damaging effects of moisture when piled tightly.

The weight of a pile of lumber is so great that it causes any temporary crib laid upon average ground to settle. This sinking has a deleterious effect on the lumber that is not generally considered. When piled on an uneven surface for a year or two, lumber that is drying out will take a permanent set. Often at least a foot has to be cut out at the bend and thrown away.

Where the supports of a pile are much shorter than the lumber there is considerable overhang at the ends. This means that these ends assume a permanent droop and have to be cut off before the major part of the piece is available; this lowers the grade of that particular piece and represents a loss on the purchase price. Ends with a long overhang will take this set even if there is no weight on top of them.

The accompanying illustrations show a method of storage that avoids all the ills cited above. This consists of a permanent cribwork made of concrete and steel. The details are shown in the drawing. The first cost of such a crib is considerably higher than the hit-or-miss kind, but it is the cheapest in the end.

Old rails, cut in two, are used. Any weight of rail that can be picked up locally is strong enough for all the timber that can be piled upon it. Worn-out rails are available in all localities and can usually be picked up at a fraction of the price of structural steel. Rails have a broad base and a good shape to imbed in concrete, with a broad, slightly rounded top. The slope of 1½ in. per ft. to the concrete foundation is about what should be given to any lumber pile in order to make it shed water. The rails also are tipped to correspond to this slope.

The depth to go for the foundation depends on the land where the lumber is stored and upon climatic conditions. A 1-3-6 mixture is strong enough for this work if the upper surface is faced with a richer mixture or troweled off with neat cement to offer greater resistance to wear. By using a taper board under the level to give a uniform slope one way and by leveling the rails, a crib that offers a flat upper surface may be made with a little extra care.

Such a lumber crib is a permanent investment. It does not have to be remade every time the pile is used up, nor do fresh sticks have to be obtained to make up for those that have rotted or been crushed. The time and expense of rebuilding the crib every time a car of lumber is received would go a long way toward the cost of the permanent installation. Also, piles of greater height are possible because of the added stability and strength. This is a factor where space is limited. The most important improvement, however, is the upgrading of the lumber itself. For example, if 10 per cent of a pile containing 5,000 ft. is lost through bending and warping, a charge of $50 or more is laid directly against the cheap crib. Boards that are crooked or warped can be placed at the bottom of the pile and, since the foundation is flat, the weight of the material above will tend to straighten them.

It is worth while to conserve lumber in this way, whether it is to be used for packing boxes or for making furniture.

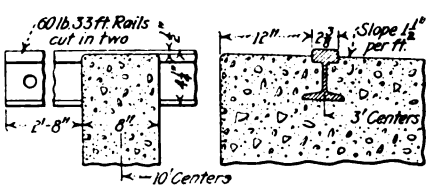
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Protecting Hair Felt Insulation on Refrigeration Lines

IN ONE plant the brine lines of a refrigeration system were insulated with hair felt, but the only protection against hard usage was a tar paper covering, held on with twine. Frequently the paper was torn and on making inquiries it was found that the maintenance costs of these lines were extraordinarily high, owing to the continued replacement of this tar paper.

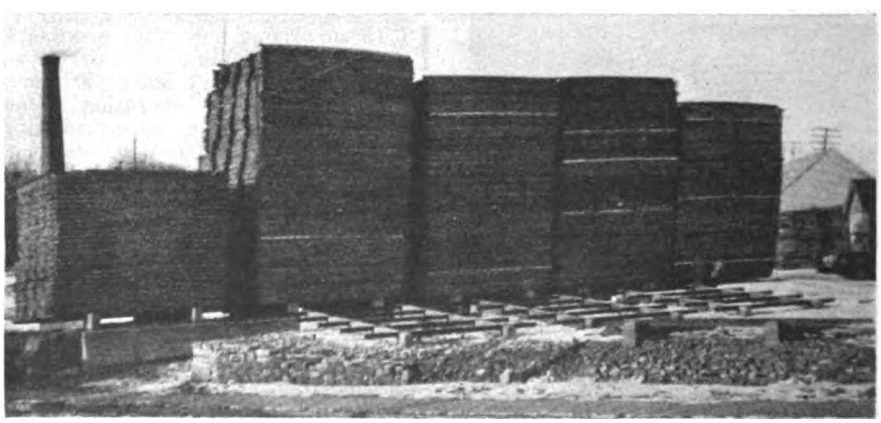
The suggestion was made to have a canvas cover put on, but the objection of the added expense was raised without regard to the expense already regularly involved. In the end, however, a muslin cover was agreed on. This, when painted over with two coats of a special tar paint, made a good impervious cover that has stood up for nearly two years of hard service. Besides being serviecable, it also looks neat, which could not have been said of the former covering.

MAURICE C. COCKSHOTT.
Los Angeles, Calif.



A crib or foundation such as this, saves lumber.

If lumber is piled on a crib like this it not only has a free circulation of air under and through it so that it does not rot at the bottom of the pile but also keeps straighter. The details of the construction are shown in the sketch above. Several piles of lumber, together with some sections of the foundation which are empty, are shown at the right.

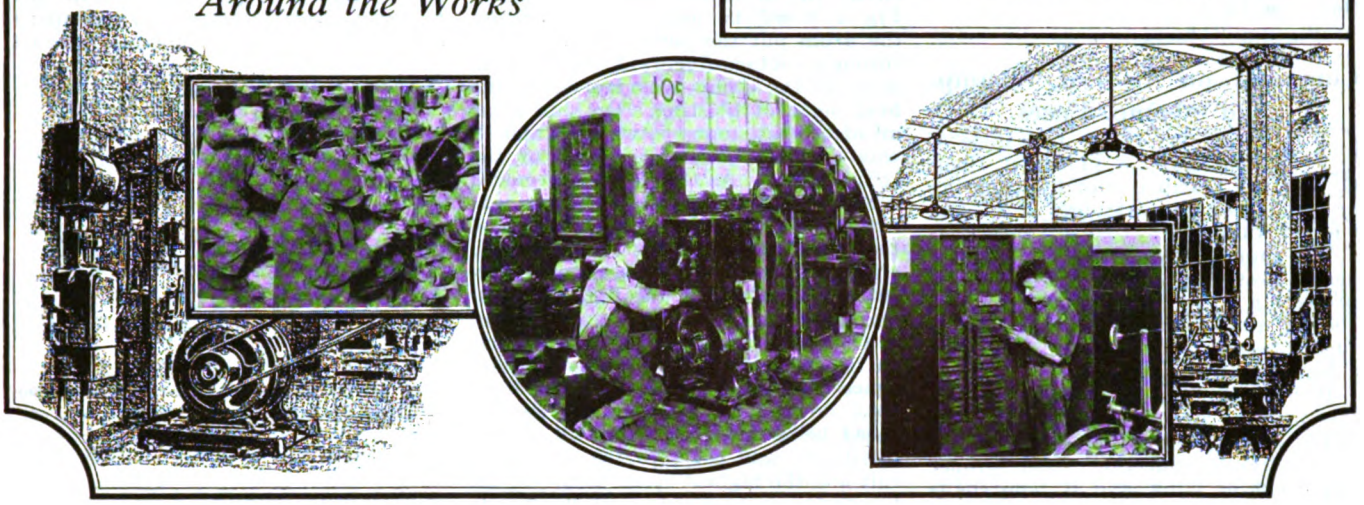


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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Device for Warning Crane Operators of Overhead Wires

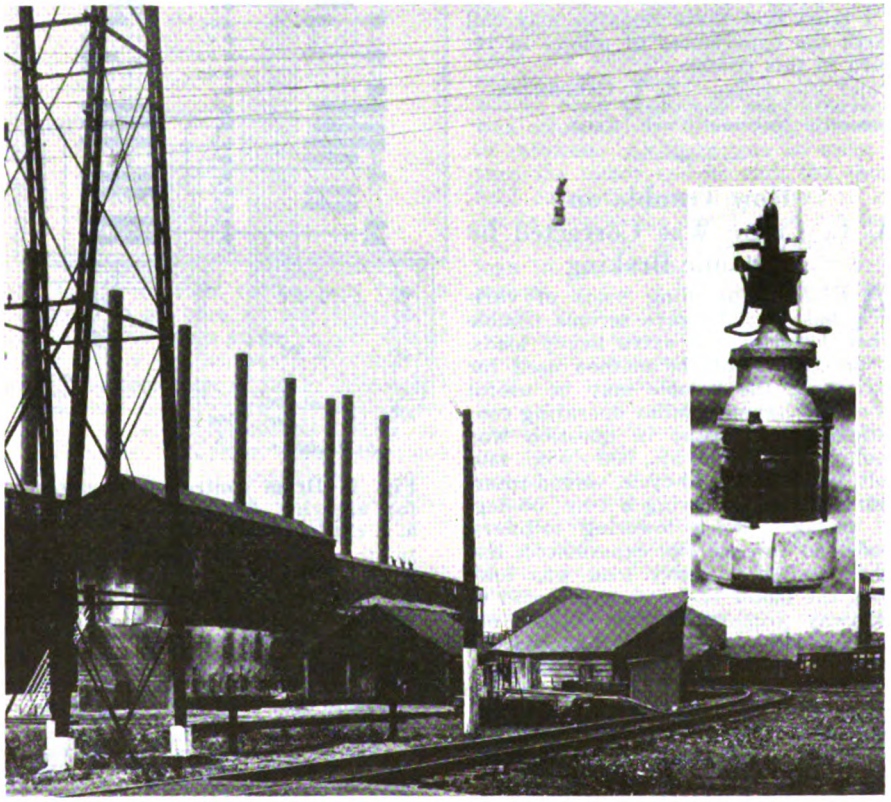
MOST industrial plant yards, and in particular many steel plant yards, have overhead lines which carry the electric power, light, telephone and signal service throughout the plant. These lines are constantly menaced by the booms of locomotive cranes wherever the wires cross over the plant railroad tracks. In the daytime the operator can usually see the wires overhead and take steps to insure that his boom does not tear them down, but at night or in twilight or fog, he cannot readily see the lines.

One plant has endeavored to remedy this trouble by installing a red warning light over the railroad track wherever wires cross overhead. A large number of these lights have been installed making a system of signal lights which has worked out very satisfactorily as it has practically eliminated the breakage of overhead transmission lines from this cause.

There are several features of this installation that are of particular interest. We felt that if we put in warning lights we must be sure that they always burned, for we knew that the locomotive crane operators would rely entirely on the lights to warn them of wires overhead. If the lights failed to burn at twilight or at night, we could almost count on a locomotive crane ripping down wires somewhere in the plant. Hence, we decided that each warning light should contain two lamps, operating in parallel, so that in the case of the failure of either lamp, the second would still be lighted, thereby allowing ample time for replacement of the damaged lamp.

A Nichols-Lintern universal signal lantern, such as shown in the accompanying illustration, was used for the warning light. The lantern has a cylindrical ruby glass lens enclosing the sides and a ruby round lens in the bottom. It is equipped with two lamps; one is a 100-watt lamp which is focused back of the cylindrical lens, and the other is a 50-watt which is focused over the bottom lens. Should either lamp fail, the other will effectively perform the double duty until the defective lamp is replaced. Hence, the lantern throws a strong red light on all sides as well as a red patch of light directly on the ground below.

It is essential that the lanterns be inspected daily to find out whether one of the lamps has burnt out. To facilitate this inspection, cleaning, and replacement of lamps, the lanterns were hung on Thompson (Thompson Electrict Co.) safety lowering switches or disconnecting hangers, as shown in the accompanying illustrations. A steel messenger cable, such as is used to support lead sheath telephone cables, is stretched between poles or adjacent buildings so that the hanger may be fastened to the messenger in position over the track, as shown in the larger



A red light suspended over the track wherever wires cross it warns the operator to lower the crane boom to prevent damage to wires.

A Nichols-Lintern warning lantern is hung from a Thompson safety hanger attached to a steel messenger, as shown in the illustration at the left. At the right a close-up view is shown of the lantern and movable part of the safety lowering switch as they appear when lowered to the ground for inspection and lamp replacements.

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illustration. With this arrangement of cable and hanger the lantern may be disconnected from the circuit and readily lowered to the ground for any inspection or lamp replacements.

Chief Electrician, R. H. BAHNEY.
The Central Steel Co.,
Massillon, Ohio.

Comment on Use of 30-amp. and 60-amp. Fuses

ON PAGE 348 of the July issue of INDUSTRIAL ENGINEER, Chas. C. Cobb, Jr., complains of the charring or burning of the cartridges of 30- and 60-amp. fuses.

The company with which I am connected uses about 2,000 of these fuses, protecting 3,000 kw. connected load of heating and cooking equipment. These fuses operate under a 24-hr. load with a load factor of .78.

It has been our experience that if the proper care is exercised in the initial installation of the cutout, as regards tight connections and proper alignment of clips, and if non-renewable fuses are used, the trouble mentioned by Mr. Cobb is negligible.

We have tried to use various makes of renewable fuses and find that they will not carry over 50 per cent of the rated cutout capacity continuously unless such elaborate care is taken at each renewal that the purpose of such a fuse, (quick and cheap renewal) is defeated.

If, for any reason, a fuse has become so hot as to burn the cartridge a great deal of future trouble will be saved if the entire cutout or at least the fuse clips can be renewed for, as Mr. Cobb points out, the causes of such a failure are cumulative and it is certain that the next fuse will do likewise unless the cutout is given the attention that such an important piece of apparatus is entitled to.

I trust that these remarks may call forth the experiences of others in regard to this trouble.

Chief Electrician, E. T. CARPENTER.
Yosemite Park and Curry Co.,
Yosemite National Park, Calif.

How Trouble on A. C. Crane Was Corrected by Dynamic Braking

A CRANE handling loads of various weights gave serious trouble when lowering the extra heavy loads. A description of the method used for correcting the trouble may be useful to others having similar operating conditions. The crane in question was equipped with a 60-hp., 600-r.p.m., 440-volt, three-phase, 60-cycle, wound-rotor, induction motor having a 1-hr., 50-deg. C. rating. When lowering ordinary loads, no trouble was experienced, but when an extra heavy load was lowered, the motor speed was increased to runaway proportions. On several occasions, the excessive speed caused the rotor to burst with resulting damage to the stator. Heavy bands on the rotor corrected this trouble temporarily, but it was considered advisable to limit the motor speed to such a degree that there would be no danger of a repetition of this trouble. Furthermore, some of the heavy loads had to be deposited on the floor very carefully.

The operation of the hoist motor had been controlled by a drum controller which varied the resistance in the rotor circuit of the motor. By referring to Fig. 1, it will be seen that in hoisting, the drum put the power on the stator through contact fingers *5*, *6* and *9* as soon as the drum was moved to the first point of hoisting. On this point all of the resistance between R_7 and R_8 was in series with one phase of the rotor circuit. As the drum was moved toward the eighth point, resistance was inserted in the other two phases and then gradually cut out until on the eighth point all of the resistance was cut out, thus giving the highest hoisting speed.

The same arrangement was in use on the lowering side of the controller; hence the motor would drive the light hook down under power, the slowest speed being obtained when all of the resistance was cut into the rotor circuit and the highest speed occurring on the eighth point when all of the resistance was cut out.

With a heavy load on the hook, the situation was, however, quite different. In this case the load pulled the hook down and overhauled the motor, thereby causing it to speed up. As soon as the speed became greater than the synchronous speed of the motor, the latter acted as an induction generator and pumped power back into the line. This action served as a brake, preventing the motor from attaining a higher speed. Under these circumstances the slowest motor speed and the greatest braking effect occurred when the resistance was

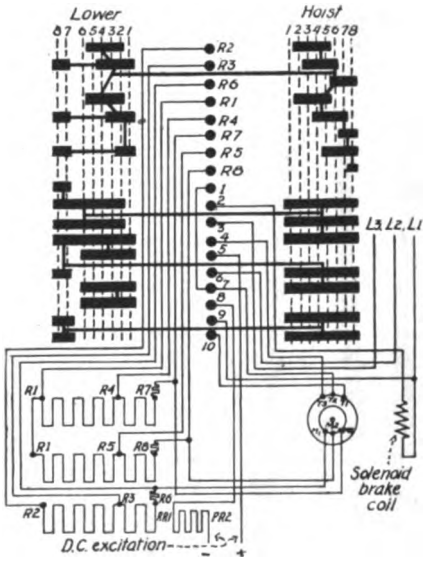


Fig. 1—Drum controller arranged for applying dynamic braking to a. c. crane motor.

In the original arrangement the hoist side and the lower side of the controller were the same. By changing the lower side of the controller so that d. c. excitation in place of alternating current could be applied to the stator on contact fingers *5* and *8*, dynamic braking was obtained. Resistance was inserted in the d. c. supply so as to limit the direct-current excitation to about 75 amp. This current is applied across one phase of the stator winding, giving about 12½ volts drop in the winding.

all cut out, as on the eighth point of the lowering side of the controller. The speed-torque curves shown at *C* in Fig. 2 show the speeds that may be attained in lowering when the hook load is sufficient to overhaul the motor. In these curves torque in per cent of full-load torque is plotted horizontally and speed in per cent of rated speed is plotted

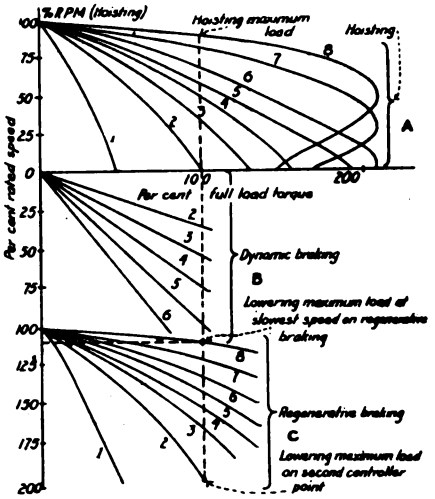


Fig. 2—Before and after performance of crane motor.

At *A* are shown the characteristic speed-torque curves of the motor during hoisting. The numbers placed beside each curve are the numbers corresponding to the point of the controller on which the motor gives this performance. With the original controller connections, these curves also applied during lowering, providing the motor drove the light hook down. If the load was sufficient to overhaul the motor, regenerative braking was obtained and lowering was according to the curves shown at *C*, which are for regenerative braking. As can be seen, the slowest lowering speed with maximum load was about 10 per cent above synchronous speed. A speed of 100 per cent above synchronism was attained on the second lowering point of the controller. This was unsatisfactory, so dynamic braking was substituted for regenerative braking during lowering. The characteristic curves for dynamic braking as used on this controller and motor are shown at *B*. This gives accurate control of the motor between 5 and 100 per cent of rated speed when lowering. The seventh and eighth points of lowering did not use dynamic braking but were arranged to give regenerative braking so as to make it possible to drive the hook down in case the load was not sufficient to overhaul the motor.

vertically. Inspection of the curves at *C* will show that the lowest speed obtainable when lowering an overhauling load is with all the resistance cut out, as on the eighth point of the controller. This is shown on curve *8*. The speed at 100 per cent torque on the eighth point is 10 per cent above synchronous speed, as can be seen from the curve. The second point of the controller, as shown by curve *2* at *C*, gives nearly 100 per cent above synchronous speed and the first point gives an even higher speed. The trouble had been caused by the operator trying to lower heavy loads on these points. It was decided that about 128 per cent of synchronous speed was as high as it was desirable to go when lowering the maximum load. In other words, the maximum speed

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that was desired should not be higher than the minimum speed that was then obtainable.

It was further decided to use dynamic braking during lowering so as to obtain this result. As shown by the characteristic curves at *C* of Fig. 2, it is theoretically impossible to get less than synchronous speed when lowering any load by means of regenerative braking. Regenerative braking may be defined as braking obtained by operating an induction motor as an induction generator. Since an induction motor must be run above synchronism before it acts as an induction generator, it can be readily seen that no braking action is obtainable below synchronism. On the other hand, dynamic braking consists of obtaining braking action by exciting the fields of a motor with direct current and pumping the generated alternating current through a resistance connected across the motor terminals. In this case the resistance was connected across the slip rings and a controller was required that would operate the motor from the alternating-current supply in the usual way when hoisting the load, but excite the field with direct current when lowering the load. Such a controller is shown in Fig. 1. The controller that had been previously used had a development or arrangement of segments and contact fingers, that was the same on both the hoisting and lowering sides.

The new controller has the same development on the hoist side, but on the lowering side provision is made for applying d. c. excitation to the stator winding on the first to the sixth points, inclusive. In moving the controller from the first to the sixth points when lowering, resistance is cut out of the rotor circuit, thereby causing less dynamic braking and permitting the motor to lower at a greater speed. On the seventh and eighth points, the dynamic braking circuit is broken and the stator of the motor is connected across the line so as to obtain regenerative braking on these points, thus giving the same speed as was formerly obtained with regenerative braking on these two points of the controller.

The advantage of dynamic braking over regenerative braking is seen at a glance by comparing the curves shown at *C* with those at *B* of Fig. 2. As can be seen from the curves shown at *B*, lowering speeds of as low as 5 or 10 per cent of full-load speed can be obtained. In other words, with dynamic braking on points *1*, *2*, *3*, *4*, *5* and *6* of the controller, slower lowering speeds are obtained than are possible with regenerative braking, as shown by the curves at *C*.

Resistance was connected in series with the d. c. excitation so as to apply 75 amp., at 12½ volts across one phase of the stator winding. With this excitation a minimum speed of 42 f.p.m. is obtained on the second point lower of the controller. Successive speeds of 74, 107, 135 and 178 f.p.m., are obtained on points *3*, *4*, *5* and *6*, respectively, of the controller. The final speed obtained on going to points *7* and *8* and using the regenerative action is approximately 200 f.p.m. This arrangement gives a speed slow enough for lowering heavy loads carefully and also, if desired, a speed fast enough for lowering a light hook is obtained by using the seventh and eighth points of the lowering side of the controller. Points *7* and *8* of the lowering side of the controller give regenerative braking if the load overhauls the motor, and if the load does not overhaul the motor, the motor will drive the light hook down.

A mechanical load brake might have been used instead of dynamic braking. With this type of brake, it is necessary for the motor to exert positive torque when lowering a light hook. This method was not considered here because the crane was subjected to continuous heavy service and it was thought that the wear and tear on a mechanical device would give more trouble than either regenerative or dynamic braking, which accomplishes braking with absolutely no mechanical friction and requires no periodical adjustment or replacement of parts.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

Current Values Required to Fuse Solid Copper Wire

WHILE the use of copper wire for fuse purposes is to be discouraged just as much as possible, occasions do arise when, due to an emergency or other good reason, it becomes necessary to use it temporarily for this purpose. In the absence of definite information as to the current required to fuse a given size of bare copper wire, it is necessary to guess at the proper size of wire to use and serious errors may be made, as the usual tendency is to select wire that has a current-carrying capacity considerably in excess of the desired value. Various other occasions arise from time to time when a knowledge of the maximum current-carrying capacity of wire of different sizes is very useful.

Fusing Current of Various Sizes of Copper Wire

B. & S. Gage	Amperes	B. & S. Gage	Amperes
10	333	18	83
11	284	19	67
12	235	20	58
13	200	21	49
14	166	22	41
15	139	23	35
16	117	24	29
17	99	25	25

Tests on wire of the different sizes given indicate that the average current required to fuse them is as shown in the table. These values apply only to bare copper wires. If they are enclosed or covered, the current value required to fuse them will be several per cent lower.

FREDERICK KRUG.
Supt. Power Construction,
Porto Rico Ry., Light & Power Co.,
San Juan, Porto Rico.

Unusual Combination of Motor and Starter Trouble

WHEN emergency replacements of damaged equipment are made it is well to see that the equipment which is put in is fitted in every respect to the service and to the controlling and other related equipment. Failure to do this may cause delays and expense out of all proportion to the original cause of the trouble. The truth of this is shown by a recent experience.

A 3-hp. motor had for some time driven a lineshaft to which were connected several machines including a heavy grindstone, which added little to the load but which had to be started slowly in order to avoid throwing its belt. This condition imposed extra duty on the 3-hp. starter and the resistance coils sometimes burned out. On one of these occasions a 7½-hp. starter was substituted for it, but the motor was not changed.

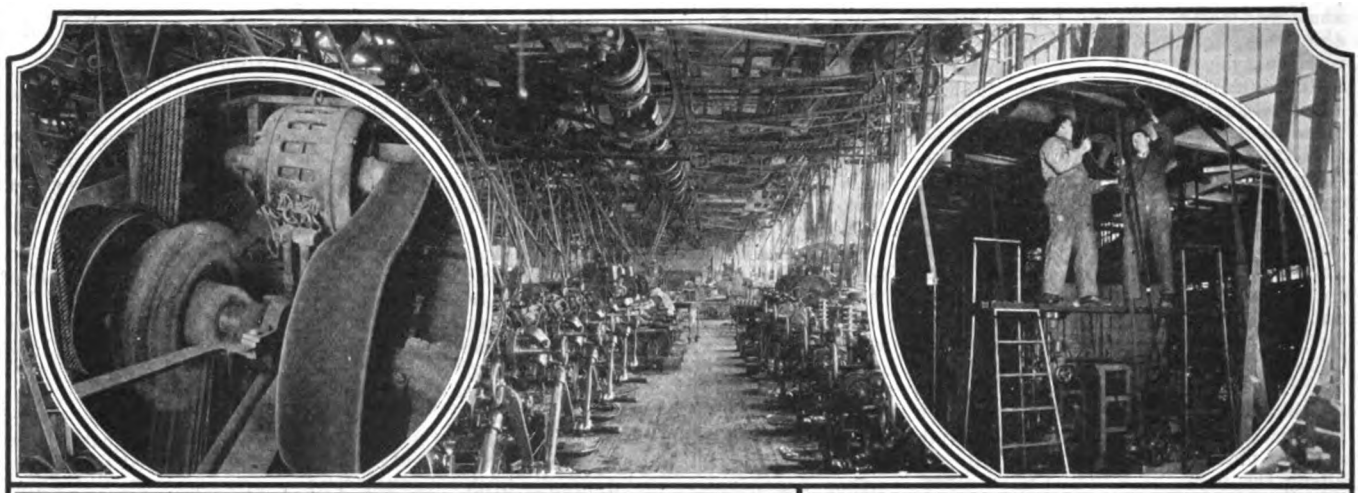
This starter was of the type that has the no-voltage release coils in series with the motor shunt field winding, and as the coil had too few turns to be strong enough when energized by the smaller current of the 3½-hp. motor, the rheostat handle was tied over with a string. One day voltage left the line and returned before anyone thought to open the line switch. The motor blew up and was replaced with a 15-hp. motor, the 7½-hp. starter being left in place. The no-voltage release coil of this starter was unable to stand the field current of the 15-hp. motor and a coil lead was burned off, thus opening the field circuit while the motor was running. This caused the motor to flash over to ground and blow the fuse.

There was nothing seriously the matter with the motor, which could have been cleaned and put back in operation, although it appeared to be much worse off than it really was. In desperation the electrician installed a 20-hp. motor and starter that happened to be on hand for another purpose. Unfortunately, this motor was compound wound and, as luck would have it, it was connected for the wrong direction of rotation. As there was no room to turn the motor end-for-end, the shunt field connections were reversed in order to reverse the direction of rotation. This placed the shunt and series windings in opposition, which was trouble enough in itself; but to make matters worse, in changing the shunt field connections an armature and field lead became interchanged. The result was that the armature was in series with the no-voltage release coil, while the rheostat resistance was in series with the shunt field winding. The no-voltage release coil burned out at once.

By this time the original 3-hp. motor and starter had been received from the repair shop. After they were installed there was no further trouble. The expense and delays which this series of misfortunes occasioned were far in excess of what they should have been and were considerably increased by the necessity of finding or making pulleys that could be used with motors of different sizes and speeds to give somewhere near the lineshaft speed desired.

Brooklyn, N. Y. J. A. HORTON.

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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

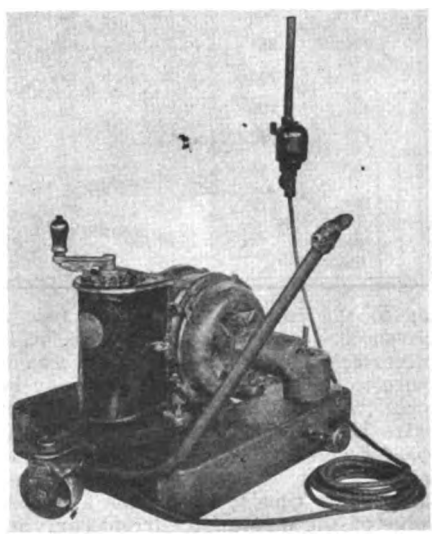
Special Base Makes Portable Motor Stationary for Temporary Drives

MANUFACTURERS of special machinery and machine tools practically always operate the machine for a short time to see that it works properly before it is packed for shipping. In some cases, the machines are so placed that they may be driven from a lineshaft. On larger machines, however, this is more difficult and the usual practice is to line up a motor so as to drive the machine where it is sitting. One problem that is often troublesome, is in providing a temporary mounting for the motor that will keep it stationary, particularly if small size motors are to be used. The accompanying illustration shows how one company which manufactures a line of special machinery for making baskets, boxes, fibre containers and other similar packages, has solved this problem.

Here the motor with its controller are mounted on a solid cast-iron base weighing 1,800 lb. This is heavy enough to hold the motor against any belt tension. When moved this motor base is supported by two small rear wheels, one of which is shown in the illustration, and the special Howe truck handle manufactured by the Howe Chain Co., Muskegon, Mich. This truck handle, shown attached to the front of the base, is provided with a single wheel and is hooked into a bracket bolted on the front end of the base. Pushing down on the handle elevates the front end from the floor so that the entire motor and its base may be pulled about wherever desired. The rollers on the rear of this base are mounted eccentrically on a shaft. Pulling back on the handle, shown attached to the roller, lowers the base onto the floor.

Whenever a machine is assembled and ready to be tested out one of the three portable motors which are mounted on the bases described above, is placed in line with the machine, belted up and placed flat on the floor by removing the handle and throwing over the eccentric rollers. Power is obtained by plugging into a nearby socket. These sockets are of the Ralco safety type with an extra wire for grounding the frame of the motor.

Two of the three portable motors are of 3-hp. and the other is of 6½-hp. rating. These are General Electric multi-speed motors connected to General Electric drum-type controllers which give speeds of 600, 900, 1,200 and 1,800 r.p.m. The motors operate on 220-volt, three-phase, 60-cycle current. Additional variations of speed may be obtained by using different sizes of pulleys. For example, each motor is fixed so that 6-in., 4½-in. and 3½-in. pulleys can be used interchangeably.



By means of a portable motor, such as this, all new machines are given a running test.

The cast-iron base upon which the motor and its controller are mounted weighs 1,800 pounds and is heavy enough to hold the motor firmly in place. The small rollers at the rear of the base are mounted on eccentric shafts, by adjusting which the base can be placed flat on the floor. These motors may be moved by the special handle and wheel at the front. This is removed when the motor is in use.

Saranac Machine Co., L. C. SHEARER.
Benton Harbor, Mich.

Quick Method of Lagging Up a Metal Pulley

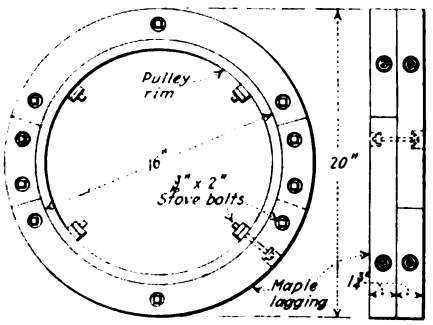
MASTER mechanics are frequently called upon to build up a pulley to larger size. This may be due to accidents to existing pulleys, rush jobs or specials that require a different speed, distance from a source of supply from which the right size could be obtained if time were given, or possession of a pulley nearly right and the lack of willingness to leave this on the shelf when the desired size can be made by building up.

In a general way, the method of doing such a job is well known but when it comes to giving a workman instructions, he asks for definite sizes. The following is given to offer an example of good practice. There are two ways of doing this work. One way is to place a series of blocks crosswise of the pulley face. This requires a number of small pieces. The other method is to cut annular pieces which fit on the curve of the pulley. This requires only a few pieces according to the thickness and width of the lumber at hand and the face of the pulley. I consider the latter to be the preferable method.

As shown by the drawing, only four pieces were required to lag this 16-in. pulley up to 20 in. in diameter and wide enough for a 3-in. belt. With pulleys of about this size this can be done when 10-in. to 12-in. planks are available to cut from. Maple or cherry make the best job, but oak or gum can be used if maple is not at hand. Ordinarily 2-in. rough lumber will dress to the thickness required here; in fact, it could be left as 2-in. stock without dressing should the occasion require it because the mating surfaces

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are drawn tightly together. In this case only one size of bolt (⅞-in. by 2-in.) is used. Bolts are double nutted where convenient to get at, to make the nuts less likely to loosen. The heads are countersunk deeply and present a safe working face. After bolting on the pieces, the pulley is turned in a lathe. It will be noticed that there is a through bolt on each side of every joint and that the joints are staggered.



When emergencies require temporary speed changes wood lagging, as shown here, may be built up quickly without permanent damage to pulley.

Working Up Discarded Belts for Small Machine Drives

AN Eastern machine shop works up discarded double leather belts in an interesting way. This shop has four long 8-in. discarded main belts that have supplied it with belt material for several years, although each of the individual belts had previously given from 20 years' service up. These belts are split and the single belts thus produced are used in the manufacturing department, where dozens of milling machines and drills use light belts, such as feed belts and spindle driving belts, of short length. On the drills, the typical drive is an open belt 1½ in. to 2 in. wide, on about 20-in. centers, and operating at high speed over rather small pulleys. Such work demands a flexible belt of considerable durability and chrome leather belts, made endless at the factory, had been used.

The plan of using one ply of the old belts did away with expenditures of this sort. With a piece of the old belt and a can of cement, one of the repair gang makes up these belts in his odd moments and they serve the purpose well.

The old double belts had been well taken care of during their life and were thoroughly run in. They had been removed because of the separation of the plies and the disintegration which followed. The men in this plant have found that they can get a lot of small belts out of the good pieces from a 50-ft., 8-in., double belt.

Another interesting point was noted in this same shop where several milling machines are rigged up with rotary fixture tables which, of course, revolve slowly. The designer of these fixtures kept the old double belts in mind when he laid out their drive. The shafts driving these rotaries are run at 10 r.p.m.; ordinarily when a practical man gets down to 10 r.p.m. on small fixtures and has considerable power to transmit, he goes to gears or chains. This man, however, put a 9-in. pulley on his 10-r.p.m. shaft and drove it on 12-in. centers from a 2½-in. pulley on a machine shaft that had ample power in it. Contrary to the usual conception of such a "freak" drive, this one does not slip and the belt is not stretched to the breaking point. A 3-in. belt cut from this same old drive belt does the work and the way it walks through the cut is a pleasure as well as a revelation; it is so soft and flexible that every fiber is pulling and clinging to the pulleys.

These drives cost practically nothing because the old belt and old pulleys were on hand, but for all practical purposes they are operating 100 per cent efficient.

Mounting a Motor with a Belt Guard to Give Headroom

MANY buildings that are used for industrial purposes were never designed for such service. To get power, light, ventilation, and transportation in such places has brought out a wealth of engineering and architectural genius from many practical shop men. For example, in one plant it was decided to do some manufacturing in a room that had formerly been used as a storeroom.

A layout of the proposed machine arrangement and a survey of the rooom showed that a line of shafting would have to be put in near one side of the room, and that the driving motor would have to be mounted on the other side, either on the floor or placed higher up on the wall or ceiling. The objection to this was that a factory trucking route through the center of the room could not be changed. This trucking aisle would also become the main aisle for the manufacturing operations.

To place the motor on the floor would require an inclined belt drive that would cut off the aisle entirely, and so could not be considered. There remained the alternative of hanging the motor from the ceiling or of placing it on a bracket that would put it at the same height. Either method would raise the lower side of the belt so that it would not interfere with the use of the aisle.

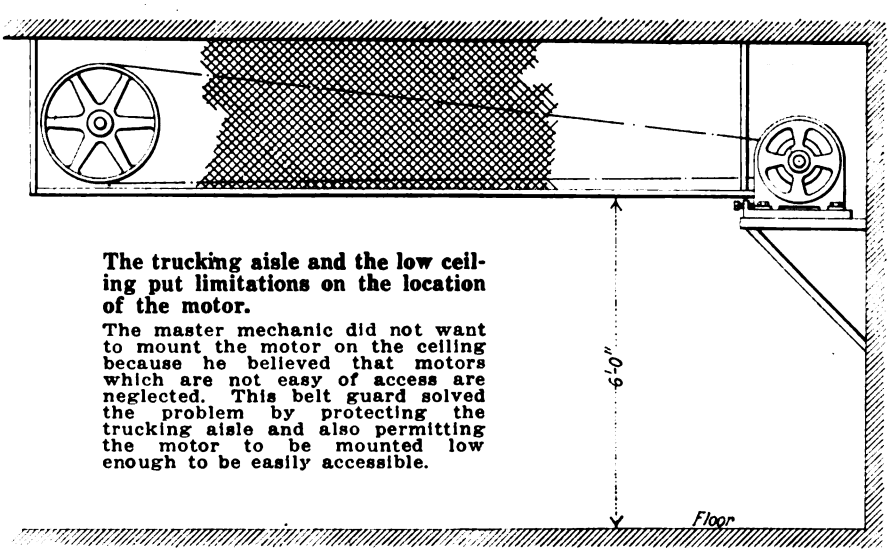
The master mechanic strongly objected because he believed that if a motor is placed at the ceiling, it is sure to be neglected. It is so high up that the oiler cannot get his head above it to see in the oil wells, and is bumping himself while working around it. He believed that a motor should be placed so that it is "get-at-able" and can receive personal attention, or it will not get cleaned or oiled or inspected as would a motor that is within reach. His solution of this problem is shown by the accompanying drawing.

A platform was erected along the side wall and the motor base bolted to it. This brought the motor about 2 ft. down from the ceiling and automatically removed the objections of the master mechanic. The lower run of the belt was then horizontal and about 6½ ft. from the floor. This was high enough to clear the head, but it would not have been good practice to allow a fast-running belt so close to a passageway, nor would it have passed safety inspection. A guard was imperative and was placed around the belt as shown.

The low belt, when guarded, permitted freer operation than would have been the case with a belt left unguarded and placed a little higher. The under side of the guard was a little over 6 ft. high and tightly boarded so that no person of ordinary height would bump into it. Also, tight mesh sides were added so that there would be no danger even if a stray piece on a truck projected above that height, or if a hand were raised to signal. Traffic and manufacturing operations could be pursued, freely.

A further advantage besides those already mentioned, was found in having the motor low down: A man could give it all necessary attention while standing comfortably on a low box. The motor was out of the way, yet accessible without lugging a ladder around. Its bearings could be felt with the hand, by standing on tiptoe.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

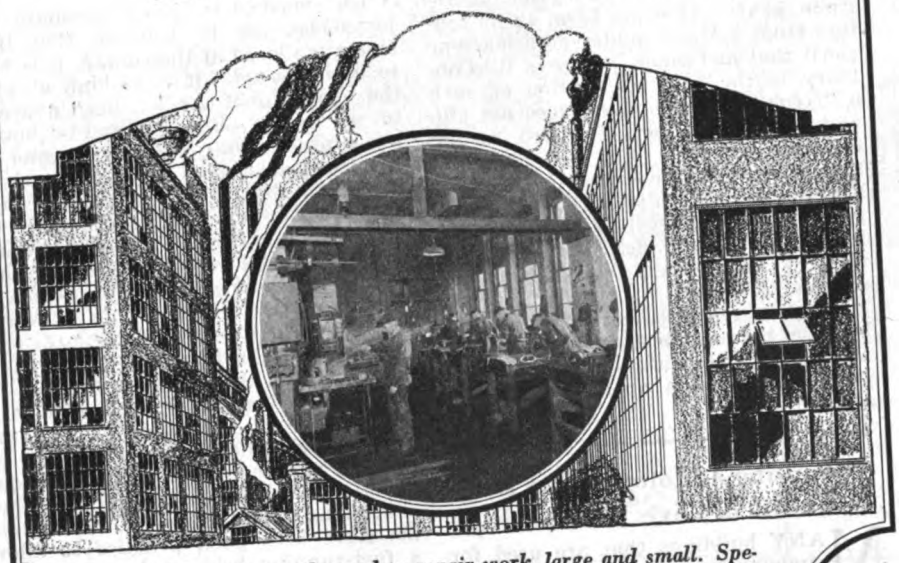


The trucking aisle and the low ceiling put limitations on the location of the motor.

The master mechanic did not want to mount the motor on the ceiling because he believed that motors which are not easy of access are neglected. This belt guard solved the problem by protecting the trucking aisle and also permitting the motor to be mounted low enough to be easily accessible.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

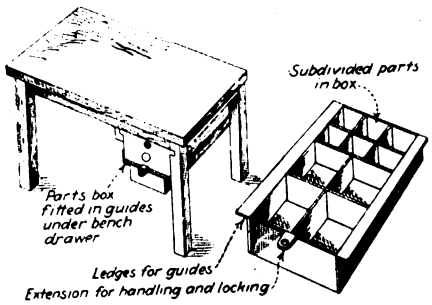
Attaching Divided Compartments to Tool Drawer

ALTHOUGH the common method of keeping separate small screws, nuts, washers, lock washers, cotter pins and other small parts varying in size, is to use small pans, divided into sections, there are times when it is desirable to have such a compartment for small parts either in or attached to a tool drawer where they may be locked up. How this was done in one shop is shown in the accompanying sketch.

A box was divided into small compartments and provided with drawer ledges as shown. The front edge of the compartment drawer is also fitted with a small extension on the front which has two uses. The drawer ledge slips in the guide and so fits snugly under the bench drawer. In this way compartment drawers can be stored away on the bottom of the bench drawer when not in service or easily removed, if desired, to be placed on top of the bench. The extension on the front of the drawer in connection with a similar piece on the bottom of the bench drawer provides a means for attaching a padlock if it is desired to lock it up. The extension also makes it easier to remove and handle the box.

A locked storage box such as this may be provided at only a small additional expense and is easily attached to the regular bench drawer. If this attachment is made rather close fitting, there is no danger of losing any of the small pieces or tools.

Washington, D. C. G. A. LUERS.



A compartment drawer is a convenient place to store small tools or loose parts. It can easily be removed and placed on the bench top, if desired, or may be locked up.

Rubber Head on Hammer for Use on Finished Surfaces

OCCASIONALLY, in repair work, particularly when hammering out dents in finished or enameled sheet metal, it is desirable to have an extra-soft faced hammer. If the repair men do not have hammers of this sort, good substitutes can be made by forcing a rubber tip, such as is used on the legs of bath stools and on the end of crutches, over the end of an ordinary machinist's hammer.

Rubber-tipped hammers also may be used for a number of other purposes such as for hammering finished woodwork to force it into position and for pounding on other finished surfaces.

Laying in a Chorded Split-Loop Winding

THE accompanying diagrams and tables give a very easy method of laying out and winding chorded split-loop windings.

Let us first examine the method of laying in the winding. The start of the winding is at S^1 in diagram *A* of Fig. 1. The first coil is wound in slots *1* and *6* and ends at F^1 in the bottom of slot *6*. F^1 is connected to S^2, the start of the

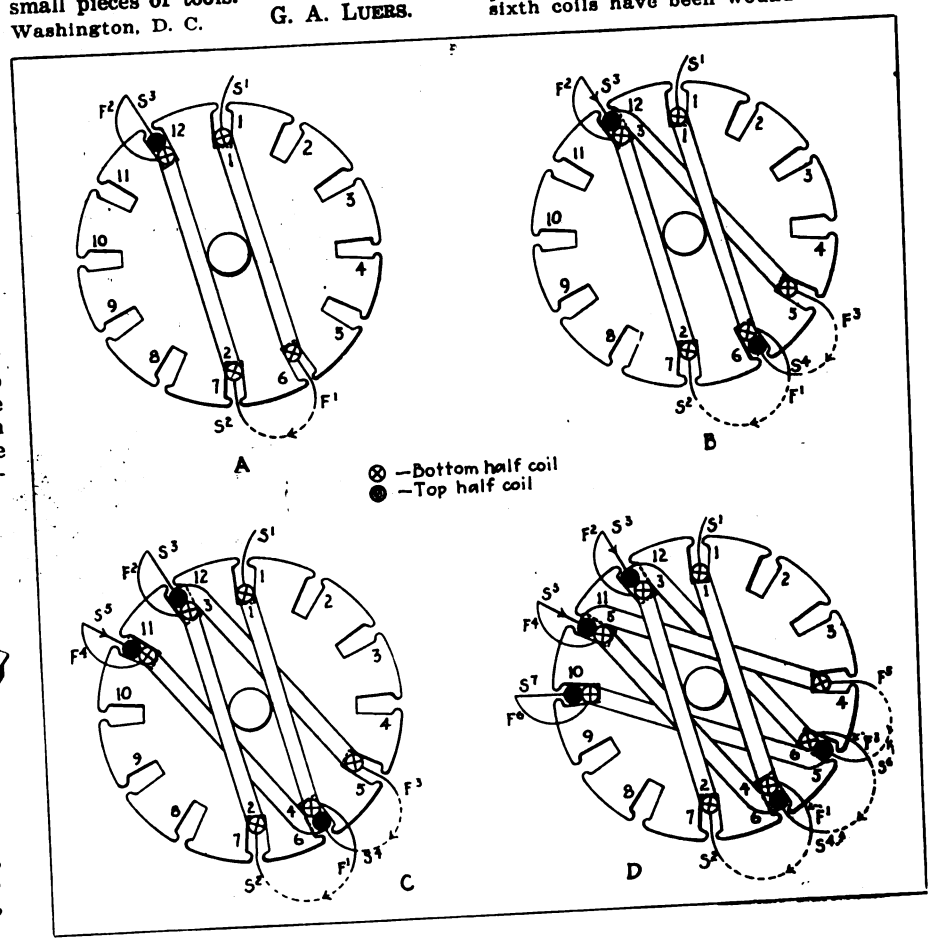


Fig. 1.—Steps in winding a chorded split-loop winding.

At *A* is shown the first parallel pair of coils placed in the armature slots. The location of the third coil is shown in *B*. *C* shows the fourth coil wound in. The third and fourth coils constitute the second parallel pair of coils. In *D* the fifth and sixth coils have been wound in.

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second coil. This coil is wound in slots *7* and *12*, and ends at F^2 which is connected to S^3, the start of the third coil.

Diagram *B* of Fig. 1 shows the third coil wound in and the start of the fourth coil, S^4 in the top of slot *6*. In diagram *C*, the fourth coil has been completed and the fifth coil started at the top of slot *11*. Diagram *D* shows the manner of laying in the fifth and sixth coils.. Fig. 2 shows the complete winding diagram, with the winding starting at the bottom of slot *1* with lead S^1 and finishing at the top of slot *7* with lead F^{12}.

It will be noticed that the coils are laid in in parallel pairs. For instance, coils *1* and *2* are parallel to each other as shown in diagram *A* of Fig. 1; likewise coils *3* and *4*, in diagram *C*.

After the first two coils are put in, it will be noticed that the slots are filled up as the winding progresses and that most of the top leads are brought out on top of the coil. This makes it easy to put them down and make a nice looking job when finished.

After once becoming familiar with this type of winding, a winding diagram such as shown in Figs. 1 and 2 is not needed. The accompanying table gives all data that the winder needs.

As an example of the use of the table let us lay out a winding for the armature shown in Figs. 1 and 2. Since this armature has 12 slots, we refer to the 12-slot column of the table and find that the winding has 12 coils wound in six parallel pairs. Reading down this column we find the number of the slot for the start and finish of each coil. It is interesting to note that with this type of winding, the last coil will always start in slot *2*.

Wilkinsburg, Pa. A. C. ROE.

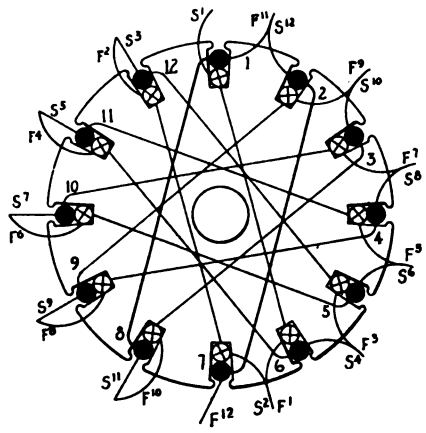


Fig. 2—Complete winding diagram for a chorded split-loop winding.

In this diagram the top half-coils are represented by black dots, while the circles with crosses in them indicate the location of the bottom half-coils. S^1 is the start of the first coil, F^1 is the finish of the first coil, S^2 is the start of the second coil and so on through the winding.

Banding a Large Armature Under Difficulties

THAT necessity is the mother of invention, is frequently demonstrated in the small motor repair shop, where the armature winder is often confronted with a serious lack of equipment. It is here that "Mother Necessity" often calls the workman's inventive powers into action.

Recently in a small shop it happened that a large armature ready for banding was found to be much too large for the only lathe in the shop. By the following method no time was lost in overcoming this difficulty.

The armature was placed on two stout horses directly in front of the lathe, the commutator lined up with the chuck and the horses blocked top and bottom to prevent slipping. After padding the commutator with canvas to prevent damage, a belt was run over the chuck of the lathe and the commutator of the armature to be banded. This makeshift took but a few minutes to erect and proved satisfactory. MAURICE M. CLEMENT.

Long Beach, Calif.

Starting and Finishing Slots for Each Coil of a Chorded Split-Loop Winding

Coil No.	10 Slots		12 Slots		14 Slots		16 Slots		18 Slots		20 Slots		22 Slots		24 Slots		26 Slots		28 Slots		30 Slots		32 Slots		34 Slots		36 Slots		Coil No.
	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish	
1	1 &	5	1 &	6	1 &	7	1 &	8	1 &	9	1 &	10	1 &	11	1 &	12	1 &	13	1 &	14	1 &	15	1 &	16	1 &	17	1 &	18	1
2	6	10	7	12	8	14	9	16	10	18	11	20	12	22	13	24	14	26	15	28	16	30	17	32	18	34	19	36	2
3	10	4	12	5	14	6	16	7	18	8	20	9	22	10	24	11	26	12	28	13	30	14	32	15	34	16	36	17	3
4	5	9	6	11	7	13	8	15	9	17	10	19	11	21	12	23	13	25	14	27	15	29	16	31	17	33	18	35	4
5	9	3	11	4	13	5	15	6	17	7	19	8	21	9	23	10	25	11	27	12	29	13	31	14	33	15	35	16	5
6	4	8	5	10	6	12	7	14	8	16	9	18	10	20	11	22	12	24	13	26	14	28	15	30	16	32	17	34	6
7	8	2	10	3	12	4	14	5	16	6	18	7	20	8	22	9	24	10	26	11	28	12	30	13	32	14	34	15	7
8	3	7	4	9	5	11	6	13	7	15	8	17	9	19	10	21	11	23	12	25	13	27	14	29	15	31	16	33	8
9	7	1	9	2	11	3	13	4	15	5	17	6	19	7	21	8	23	9	25	10	27	11	29	12	31	13	33	14	9
10	2	6	3	8	4	10	5	12	6	14	7	16	8	18	9	20	10	22	11	24	12	26	13	28	14	30	15	32	10
11			8	1	10	2	12	3	14	4	16	5	18	6	20	7	22	8	24	9	26	10	28	11	30	12	32	13	11
12			2	7	3	9	4	11	5	13	6	15	7	17	8	19	9	21	10	23	11	25	12	27	13	29	14	31	12
13					9	1	11	2	13	[3	15	4	17	5	19	6	21	7	23	8	25	9	27	10	29	11	31	12	13
14					2	8	3	10	4	12	5	14	6	16	7	18	8	20	9	22	10	24	11	26	12	28	13	30	14
15							10	1	12	2	14	3	16	4	18	5	20	6	22	7	24	8	26	9	28	10	30	11	15
16							2	9	3	11	4	13	5	15	6	17	7	19	8	21	9	23	10	25	11	27	12	29	16
17									11	1	13	2	15	3	17	4	19	5	21	6	23	7	25	8	27	9	29	10	17
18									2	10	3	12	4	14	5	16	6	18	7	20	8	22	9	24	10	26	11	28	18
19											12	1	14	2	16	3	18	4	20	5	22	6	24	7	26	8	28	9	19
20											2	11	3	13	4	15	5	17	6	19	7	21	8	23	9	25	10	27	20
21													13	1	15	2	17	3	19	4	21	5	23	6	25	7	27	8	21
22													2	12	3	14	4	16	5	18	6	20	7	22	8	24	9	26	22
23															14	1	16	2	18	3	20	4	22	5	24	6	26	7	23
24															2	13	3	15	4	17	5	19	6	21	7	23	8	25	24
25																	15	1	17	2	19	3	21	4	23	5	25	6	25
26																	2	14	3	16	4	18	5	20	6	22	7	24	26
27																			16	1	18	2	20	3	22	4	24	5	27
28																			2	15	3	17	4	19	5	21	6	23	28
29																					17	1	19	2	21	3	23	4	29
30																					2	16	3	18	4	20	5	22	30
31																							18	1	20	2	22	3	31
32																							2	17	3	19	4	21	32
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36																											2	19	36

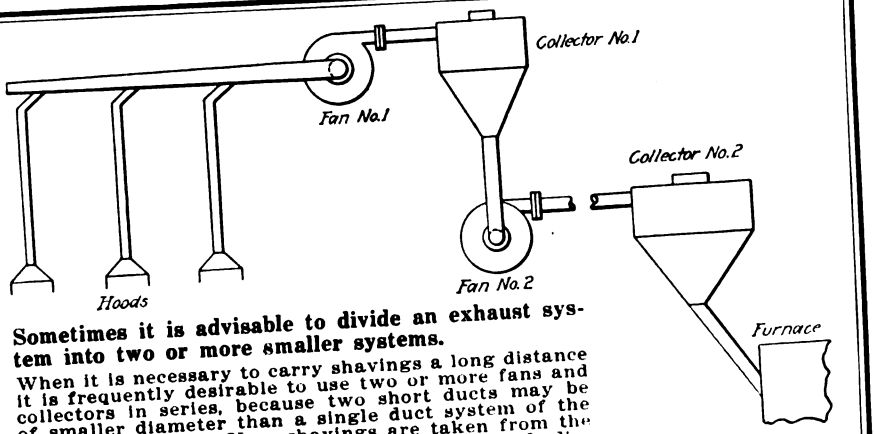
In each column, one line is marked "Start" and the other "Finish." This refers to the number of the slot in which the coil starts and to the number of the slot in which the coil finishes.

The first line in each column gives the winding pitch.

The parallel pairs of coils for a winding having a given number of slots are enclosed in the horisontal lines in the column labelled with the given number of slots.

Note that with this type of winding, the last coil of the winding always starts in slot 2.

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Sometimes it is advisable to divide an exhaust system into two or more smaller systems.

When it is necessary to carry shavings a long distance it is frequently desirable to use two or more fans and collectors in series, because two short ducts may be of smaller diameter than a single duct system of the same total length. Here shavings are taken from the machines through two collector systems and discharged into a furnace.



The intake of the pneumatic handling system at the Charlottesville Woolen Mills.

This pneumatic collecting and conveying system handles wool to and from various parts of the plant as well as the refuse from wool and woolen waste. By shifting the damper in the intake pipe on the floor, material may be removed from the room back of the fan or from another room through the suction pipe which goes up through the wall. Similarly the material is discharged wherever desired through various duct outlets.

Handling Materials by Air

(Continued from page 431.)

used to handle shavings except that special fans are required with vanes which will not catch stringy material, as in this type of conveying the material passes through the fan. The advantage of this is that the material is kept clean and can be moved quickly and economically. In some cases, particularly where the material does not contain dust, the storage rooms serve as a separator.

The other two methods of pneumatic conveying are generally used in connection with materials or products which have more or less powdered or pulverized material in them. One of these is known as the vacuum system and the other as the pressure system of pneumatic conveying. The vacuum system consists of a pipe or hose, the end of which is inserted into the loose material to be moved, a conveying pipe, a separating system and an exhauster. The arrangement of these varies somewhat to fit the problems of the installation and the material handled.

In general, practically any heavy material is taken out of the line ahead of the exhauster. In some cases a filter is placed back of the exhauster to remove any fine dust before it is discharged into the atmosphere. More frequently, some form of filter is placed in the line just after the separator so that all dust is removed before entering the exhauster. The inlet to this separator consists of a long pipe with several branches so that connections may be taken off for unloading at different locations. Such a system is very frequently used for unloading cars into storage and also for moving from storage to other places in the plant. Some of the various types of filters and separators which may be used in connection with a pneumatic conveying system were described in the article entitled, "Separating Dust from Air in Industrial Plants," which appeared in the August issue of INDUSTRIAL ENGINEER.

The capacity of such a system varies according to the distance handled, the material, and the diameter of the intake line. Material can be handled vertically as well as horizontally and the pipe lines may be located anywhere out of the way. Such equipment is commonly used for unloading materials from cars and boats. In one case a conveyor line over 400 ft. long, which handles acetate of lime in a 2½-in. pipe, conveys about 2½ tons an hour. About 19 hp. is required to operate the vacuum pump. This material varies from lumps the size of a bean down to fine material and weighs about 30 lb. per cu. ft. In another case an aluminum company handles about 20 tons of bauxite per hour from the car to the separator which discharges into the storage tank, a total distance of about 142 ft. which includes a vertical lift of 72 ft. This material is extremely fine and weighs about 65 lb. per cu. ft. Two 3-in. hose lines are used and about 75 hp. is required to operate the equipment.

The pressure system of pneumatic conveying operates at either high or



Cotton may be handled pneumatically at a very low cost.

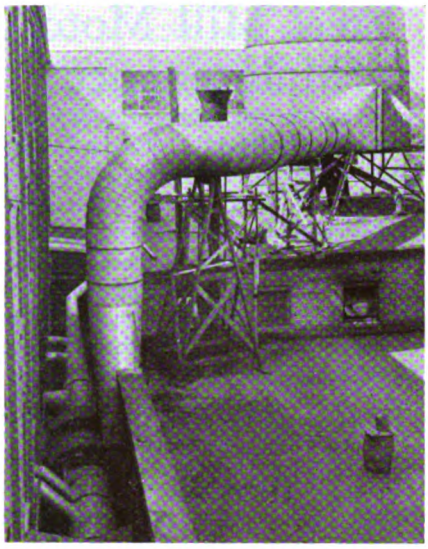
This illustration shows a part of the duct work and the cyclone collectors at the Valley Waste Mills, La Grange, Ga., which collect and convey the refuse from the willowing machines.

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low pressure. In the low-pressure system the blast is produced by a fan while in the other high-pressure blowers are used. With the low-pressure systems from 50 to 100 cu. ft. of air are required for every pound of material conveyed, depending upon the weight and nature of the material, conveying distance, and so on. Under the high-pressure system from 2 to 10 cu. ft. of air are used for the same purpose.

With the low-pressure pneumatic conveying system the velocity of air used may vary from a few hundred to 5,000 or 6,000 ft. per min. However, under the high-pressure system the velocity ranges from 3,000 to 20,000 ft. per min. Under either type of pressure system some means are used to feed the material into the pipe lines which at the same time does not permit the escape of the air and the lowering of the pressure. Generally the material is fed into the blast line through a specially-built ejector.

The blast in a low-pressure system is produced by a standard fan and material is collected in a metal centrifugal separator. When the volume of air handled and the pressure are comparatively low, galvanized or sheet-iron pipes are used for the ducts. On the high-pressure system the pipe diameter is small and the pipe is more substantial and may be placed in any position. In some cases, owing to the small volume of air handled under the high-pressure system, the material, if it contains only a small amount of dust, can be blown directly into the storge bin where most of it settles down. The air in the storage bin can then be pulled through a filter and the dust separated if necessary. In most cases the material goes through a separator which removes all of the coarse and some of the fine material; the fine dust is then removed as the air passes through a filter. The clean air is then drawn out through an exhauster.



The fan and collector system at the American Seating Co., Grand Rapids, Mich.

Here two large exhausters are installed in the center of the collection system and discharge into a dust separator. Each of these systems is made up of several smaller inlets which discharge into them.

There is still another type of pneumatic conveying which is commonly known as a pneumatic tube system. While these were originally installed in department stores for carrying cash to a central cashier's office and the change back to the purchaser, they have lately been installed in many industrial plants to carry production orders, or blueprints, or other information between departments and factory offices, and in some cases to carry small tools. In these systems use is made of a cartridge which fits snugly into a tube and is drawn along by withdrawing the air in front of it or pushed along by air pressure applied behind it.

In plants generating their own power by steam, the handling of ashes enters largely into the problem of waste disposal, in those cases where coal is the fuel employed.

While this is not strictly within the scope of the present article, it should be mentioned briefly, especially in connection with pneumatic conveyors. Ashes are handled by manual labor in wheelbarrows and cars of various kinds, and also by various types of mechanical conveyors, as well as current conveyors which include the hydraulic, vacuum, and steam-jet types of conveyor.

Only the last two will be considered in the present case, as these alone make use of principles already described. The vacuum conveyor consists of an air-tight storage tank, with a turbine or motor-driven centrifugal exhauster for maintaining a partial vacuum. From the tank a pipe line extends to the pits or furnaces from which the ashes are to be removed. This line is provided with intake fittings at the proper points, which can be tightly closed when not in use.

An air intake is essential at the extreme end of the line to maintain the necessary current when the ash intake opening is practically closed by the ashes being fed through it. In order to remove the fine dust from the air passing from the tank to the exhauster it is necessary to install some form of washer between these points.

The steam jet conveyor consists primarily of a line of pipe into which ashes are fed, and through which they are carried to a discharge point by a current of air similar to that in the vacuum system. In this case, however, the suction is produced by the aspirating effect of a steam jet placed just beyond the last intake opening on the storage tank side. The line from this point back to the air inlet at the end is called the suction line and that portion between the steam jet and stor-



Handling waste paper by air in a paper mill.

This shows pneumatic conveyor outlets for handling waste paper at the Michigan Paper Co., Plainwell, Mich. The paper is brought from the sorting room and discharged at various places in the room by means of regulating dampers.

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age tank, the discharge line. Ashes in the first portion are moved by suction, and in the second portion are driven by the force of the steam jet.

No attempt will be made to compare the advantages and disadvantages of these two systems or to go into details of construction. The advantages of both as compared with mechanical conveyors of various types are their flexibility and ease of installation, as it is possible to reach almost any point and to move the ashes in any direction by the same equipment. Another important point is the matter of cleanliness, which has a strong bearing on industrial establishments where dust and dirt must be avoided. Also, any gases which may be given off are sucked into the pipe and so removed.

Handling materials by means of air has many advantages. Among the most important of these are: the flexibility of the system, the automatic removal of dust and fumes while handling, the small amount of moving parts and power used, and the economy which results largely from the small amount of labor required in connection with the operation. Industrial plants which have a problem in connection with handling any light material, particularly materials which give off dust, will find it worth while to investigate how air might be used to advantage.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and other articles which have appeared in this series: The Air Conditioning & Engineering Co., St. Louis, Mo.; Allen & Billmyre Co., Inc., New York City; American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; E. B. Badger & Sons Co., Boston, Mass.; Bentz Engineering Corp., Newark, N. J.;; Buffalo Forge Co., Buffalo, N. Y.; Carrier Air Conditioning Co. of America, Buffalo, N. Y.; Carrier Engineering Corp., Newark, N. J.; The Clarage Fan Co., Kalamazoo, Mich.; The Cooling Tower Co., Inc., New York City; The Dust Recovering & Conveying Co., Cleveland, Ohio; Globe Ventilator Co., Troy, N. Y.; Green Equipment Corp., Chicago, Ill.; Holly Pneumatic Systems, Inc., New York City; Ilg Electric Ventilating Co., Chicago, Ill.; The MacLeod Co., Cincinnati, Ohio; The Martindale Electric Co., Cleveland, Ohio; Mellish-Hayward Co., Chicago, Ill.; Midwest Air Filters, Inc., New York City; D. J. Murray Mfg. Co., Wausau, Wis.; The Northern Blower Co., Cleveland, Ohio; Research Corp., Chicago, Ill.; Reed Air Filter Co., Inc., Louisville, Ky.; P. H. & F. M. Roots Co., Connersville, Ind.; Spray Engineering Co., Boston, Mass.; B. F. Sturtevant Co., Boston, Mass.; Standard Conveyor Co., N. St. Paul, Minn.; The Temco Electric Motor Co., Leipsic, Ohio.

Steel Mill Motor Maintenance

(Continued from page 426)

presence of dirt may cause a failure, even when the machine is in good condition. While it is unfortunate that insulation must be subjected to the danger of breakdown in order to find out if it is in proper condition, this should not deter the operating engineer from making such tests at reasonably frequent intervals.

VOLTAGE THAT SHOULD BE USED FOR HIGH-POTENTIAL TEST

There is a variety of opinions as to the best percentage of operating voltage to apply when making a high-potential test. The double voltage applied when the apparatus is new is presumably a larger margin of safety than is reasonable after the apparatus has been in service for a period of years. It is the writer's opinion that 150 per cent of normal voltage is the minimum to which the insulation should be allowed to deteriorate. If the insulation will break down on the application of 150 per cent of normal voltage, the apparatus should be rewound or some other radical steps taken.

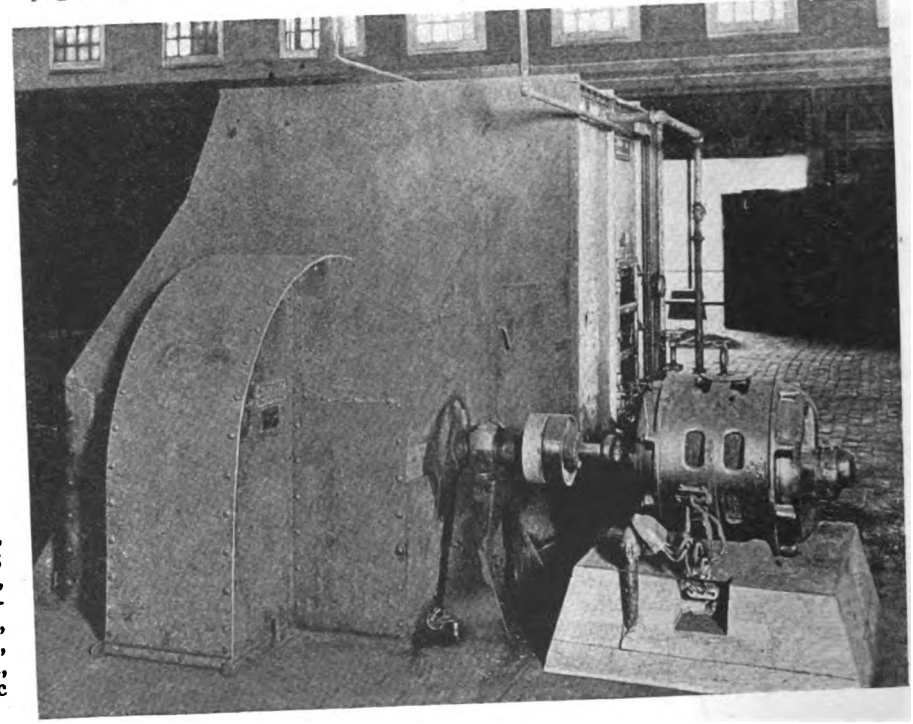
High-potential tests should be made with caution. The machine should be thoroughly cleaned. The insulation must be dry and show a good resistance value. When making tests the testing terminals should be placed on the machine while the circuit is dead and the high voltage applied by closing the low-voltage circuit breaker. When the test is completed the high voltage should be removed by opening the low-voltage circuit first and then removing the test leads.

The severity of the test depends to a marked degree upon the time the test voltage is applied. The writer would suggest that this test be applied for a period not longer than one minute.

At regular intervals steel mill motors and electrical apparatus should be thoroughly overhauled both mechanically and electrically. The mechanical overhauling should include the tightening of all bolts and nuts, attention to bearings, shafts, couplings, alignment, balance, air gaps, and the like. The electrical overhauling should give attention to all connections, commutators, slip rings, insulation, etc. This should be done at least once a year. The insulating varnish mentioned above can be applied at this time and a high potential test may be applied to the insulation. Local conditions will dictate the time of year when a unit can best be spared for a long enough period to make the test or to make repairs in case of a breakdown which might occur as a result of the test.

To sum up the situation, large steel mill motors generally do not show signs of distress until the

Here is the air washer and blower installation used for supplying clean air to the hot sheet mill motor shown in the illustration on page 423.



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trouble has manifested itself in an actual breakdown. It is therefore essential to exercise considerable vigilance and maintain the motors in good condition if the user is to enjoy a maximum of service with a minimum of maintenance expense and delay in operation.

A section devoted to the question of drying out machines may properly come within the scope of this article. Machines may become wet due to some accident and they frequently are wet during the period of installation and before they are first placed in operation. If the machines become wet at any time they should be thoroughly dried out before being again placed in service. This can be done by applying heat externally or by circulating current in the windings. Drying out by applying heat externally can be done by placing resistance grids under the machine to dissipate roughly about one kilowatt per 100-hp. rating of the machine. Care should be taken that no part of the hot grids comes in contact with the windings. The machines should be covered with a tarpaulin and an opening provided at the top to allow the escape of the moisture, otherwise, it will condense on the machine again as soon as the heat is discontinued. A thermometer should be kept on the machine and the temperature not allowed to exceed 100 deg. C. unless it is known positively that the insulation is of such a nature that higher temperatures will not be injurious.

The time required to dry out a machine thoroughly will vary from a few days to several weeks depending on the size of the machine and the condition of the insulation when starting. Insulation resistance should be determined two or three times a day at uniform intervals during the period of drying out. A curve should be plotted using resistance as ordinates and hours as abscissae. Methods of taking insulation resistance have been described earlier in this article.

Machines that have been dried out by applying external heat only may show a very good value of insulation resistance with a megger and still have moisture in the insulation next to the conductors. This is particularly true of high-voltage machines where the insulation is heavy and it is very difficult to entirely dry out the moisture. Hence a much more effective method is to apply the heat internally by circulating currents. Machines of 2,200 volts or higher can generally be dried by applying 220 volts alternating current simply by connecting this circuit to the terminals without interposing resistance. The machines can be watched very closely at first by observing thermometers placed on the coils to make sure that they do not overheat. The application of current directly to the coils presupposes that the insulation is in good enough condition to withstand this low voltage. If the insulation is in poor condition, external heat should be used until it is safe to apply a low voltage for circulating currents. The same process of taking readings of insulation resistance should be followed as has been described for external heating, until the insulation resistance reaches a fixed value.

The American Institute of Electrical Engineers recommendation for insulation resistance is: Megohms = Voltage ÷ (Kva. + 1,000). This value seems to be low and for some mill apparatus, particularly 2,200-volt machines, the machines should show at least one megohm per 1,000 volts. These values are not given with the understanding that the drying-out process should be stopped when these values are reached, but in every case, the process should be continued until a constant value is obtained. If this constant value does not equal that given above, the manufacturer of the apparatus should be notified.

Problems of Steel Mill Operation

(Continued from page 414.)

More attention is being paid to the remainder of the switching equipment. One operator told of using an interlocking system on his disconnects whereby it was impossible to unlock the enclosures around the disconnects until the oil switch had been opened. At another installation in the Pittsburgh district the disconnects are gang operated. The switchboard operator opens or closes the disconnects manually, but at a distance from them. An auxiliary switch is so arranged that when the disconnecting switch blades are moved a short distance, and before they are open, it will complete the trip circuit on the oil switch, thereby opening the latter.

More interest is also being shown in the arrangement of buses and their bracing so as to give additional strength against short-circuit conditions. This is in line with the increased attention that has been paid to the rupturing capacity of circuit breakers, which has been mentioned previously in this article.

Most of the foregoing developments in substations have been brought about as the result of a desire for increased reliability of operation and safety to the operating personnel. One plant in the Chicago district that is not using truck-type switchboards, is using remote control for all circuit breakers, including all of the alternating-current and direct-current feeders, the carbon circuit breakers on the generators of motor-generator sets, as well as the magnetizing, starting, and running switches for the synchronous motors on these sets. The electrical superintendent in charge of this plant said that not only did this provide greater safety, but that it also greatly simplified the arrangement of the buses and feeders.

The search for the best all-around system of yard transportation continues slowly because of the excessive investment charges. Installations of third rail systems have been made, and have seemingly demonstrated that they can be operated without excessive danger to employees. A plant in the Youngstown district is trying out a storage battery locomotive for this work. Considerable interest was expressed by several operators in the Diesel-electric locomotive, the development of which is proceeding very satisfactorily. When production permits reasonable first cost, its very attractive operating characteristics will undoubtedly bring it into general use in steel plants.

Trends in Use of Electric Heat in Steel Mills

The use of arc welding as a means of repairing worn and broken parts in steel mills has shown a great increase during the past year. The savings effected by arc welding a single worn or broken part have in a number of instances more than paid for the first cost of the welding equipment. Automatic arc welding is being used in some plants for building up worn shafts and for similar operations.

Conditions in the development of

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arc furnaces for melting steel and iron have become fairly well established. There continues to be a steady, although slow, development of low-frequency induction furnaces for making high-grade steels and alloys. The field of the high-frequency induction furnace, however, has shown one of the most interesting developments of recent years. For many years it was thought that the high-frequency induction furnace could not successfully melt metals at frequencies lower than 5,000 cycles. However, it has been recently demonstrated that frequencies approximating 500 cycles will melt metals on a commercial basis with good efficiency.

With the expiration of patents covering certain alloys of great value for use in resistor units, a new impetus has been given to annealing and heat-treating furnaces.

Furnaces of large capacity with temperatures of 1,800-2,000 deg. F. are being installed in considerable numbers. Two electric furnaces for the continuous hardening, quenching and tempering of carbon-steel wire have been recently installed in wire mills. This process is said to result in a higher quality of wire than when the latter is treated in a gas-fired furnace.

Considerable interest has been displayed in an electrically-heated soaking pit which was installed by the Donner Steel Company a little over a year ago. These pits are heated with resistor-type units. The principal advantages claimed for this type of pit are more uniform heating due to accurate control of temperature, elimination of scale while in the pit, elimination of cutting of the ingot as in the case of sharp gas flames, and production of a better surface on the blooms. There is also a saving in space over gas-fired pits as well as a saving in foundations. When taking into consideration the saving in scale and with the usual cost of steel mill power, it is said that the cost of heating is less than by any other means, provided the ingots can be charged into the pits at such temperatures as are now common in steel mill practice. One steel mill engineer interviewed was particularly interested in the scale saving. This he said was an important factor in heating alloy steel such as is the product of his plant.

Reduction of inventories is being considered more carefully than ever before. It is hard to reduce inventories of spare parts after an installation has been made, but quite often a little foresight at the time of making an installation will save much money in spare parts. One engineer interviewed said that he was purchasing his motor equipment for a given installation at the very last. At this time he knows all of the details on all drives. It is then quite often possible to standardize on the capacities of motors required. Also, at this time it is usually possible to lay out the drives so as to cut down the number of speeds required. Similar capacities and types of motors are then purchased from only one manufacturer. The same is true of control equipment.

Another engineer stated that he was standardizing on the sizes of large motors as much as possible. He was also having this standardization carried to the bearings, coils and other parts of the motors. He said that by cutting the variety, sizes and types to a minimum he had been able to effect a saving of 50 per cent in the amount of spares mentioned in the original proposal. This, all of us will agree, was decidedly worth while.

Pointers on Winding D. C. Armatures

(Continued from page 435.)

(2) When the center line of the coil falls on the mica, bar *M* is located by the use of the following formula: (lead pitch+active coils per cell)÷2. For example, assume that there are 47 slots, 93 bars, two coils per cell, one dead coil, coil pitch 1-and-11, or 10, lead pitch 1-and-47, or 46. The center line will fall on mica and slot, and slot *F* equals (10+2)÷2=6; bar *M* equals (46+2)÷2=24. Bar *N* equals 25, and bar *P* equals 47.

The above rules and formulas use the center line of the coil for laying off the winding data and can be used for any number of poles. The slots and bars should be marked as already explained.

The marking of the winding data on the core and commutator has the following advantages: When a sample coil is brought in from the coil department to check for throw, end room, etc., there is no time lost hunting up data, as the coil pitch is stamped on the core and the use of one cross on either side of the bottom slot also tells the coil man whether the coils should be right- or left-hand. In plants that do their own winding the marking of the slots eliminates the necessity of taking data the second time the armature comes in the shop for rewinding. All that is necessary is to check the lead pitch and the markings on the commutator in relation to the core markings to insure that the data have not been thrown off by commutator repairs. This check will only take about ten minutes to make and then the armature can be stripped by cheap help. Also, on four-pole machines the proper lead pitch is insured.

Next, we come to the cases where a half-idle bar is used. This type uses the diagram shown in Fig. 3 *B* and the rules governing the number of coils per cell, coil and lead pitch, line up of coil center line, etc., are the same as were given in connection with Fig. 3*D*, July issue, page 334, except that bar *M* equals [(commutator pitch)+(number of active coils per cell)—1]÷2, and bar *S* equals (commutator pitch+number of active coils per cell)÷2, and bars *x* and *y* are connected together by means of coils *1* and *2*. The first single coil to the left in the bottom of slot *1* should have its bottom lead cut off short, that is, not brought out to the commutator, and this short coil soldered to the adjacent coil lead in the same slot and to the right. Then the half-idle bar will be either bar *x* or *y*. These two bars should be considered as one bar in counting off lead pitch, etc. When stripping an armature that has one turn of strap copper coils and where it is desired to reinsulate the coils and use them again and the armature has a half-idle bar, the bottom coil leads should be numbered, calling the strap connecting to bar *1*, (Fig. 3 *B*,) No. 1, to *T*, No. 2, and to *R*, No. 3. Continue the lead marking until past bar *x*. The reason for this is that due to the bottom lead being cut off, and the half-idle bar, the remaining leads are stretched one bar until past the data coil. If the coils from another section of the armature were used at this point, they would not extend out flush with the outside surface of the commutator. In fact, a large number of winders mark all strap copper coils when reinsulating them, regardless of whether or not a dead coil or half-idle bar is used. This is a good policy to follow on old armatures, if the core is spread, but the starting slot should also be marked so that the winding will start in the same place on the core. Also, see that the coil leads are marked in the order in which they will be put back.

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The top leads are generally the ones marked for left-hand coils. Start with the first single top coil to the left of the slot and call this No. 1, and make the numbers run clockwise. Then when rewinding, put in the coil with lead numbers 1, 2, 3, first; then coil leads 4, 5, 6, etc. For right-hand coils, call the first single top coil to the right No. 1 and mark the rest in a counter-clockwise direction.

Graphic Meters for Detecting Grounds

(Continued from page 417)

Chart *B* of Fig. 3 shows the record taken at No. 3 substation at the same time. The ground appeared on this chart at 3:30 p.m. but the deflection continued on the chart during the period between 3:40 and 3:45 while the tie line connecting No. 2 and No. 3 substations was open. This clearly proved the trouble to be in the distribution from No. 3 substation.

These charts also showed that the ground was on intermittently as though it were a crane or some other start-stop drive that only operated for a very short period of time during its regular cycle of operation. Also, as can be seen from the charts, intermittent deflections are shown for a period of 20 min. which is followed by a corresponding idle period of 20 min.

This enabled the men to know that the ground was on one of the two billet chargers, for only one is in operation at a time and the operation of each one is limited to 20 min. periods.

Charts *D* and *E*, shown in Fig. 3, show the difference between a reversing and a permanent ground. Chart *D* is a reversing ground of the type found on the brush holder of a crane motor. Chart *E* is a permanent ground such as would occur from the grounding of a hot rail, feed line or collector ahead of the controller. Chart *C* of Fig. 5 shows a ground that reverses at intervals of about 10 min. and is of short duration.

Chart *F* of Fig. 5 shows a chart taken from No. 5 sub-station. Just before 10 a.m. a ground appeared that was quickly located on the brush holder of No. 6 squaring shear motor. Twenty-five minutes later another ground appeared which was not located and cleared until after 11 o'clock. When traced down the ground was found to be on the trolley bar of No. 31 crane.

An operating man must know the individual characteristics of his plant in order to derive full benefit from the graphic record of the grounds. However, a little study of the duration and interval of operation of different machines will enable him to definitely locate a faulty motor without the usual troublesome opening of circuit breakers and switches in the various power distribution stations and then haphazardly guessing at the machine in trouble until he finally locates the right one, which in some cases might be the last one tried.

In the plant in which these graphic ground detectors are installed there are 12,285 connected horsepower of motors. We find that with a graphic record of faulty d. c. equipment, the men follow up their work much closer. In addition to a material saving in maintenance costs, accurate records of all delays on d. c. equipment show that there has been a reduction of 26 per cent in production delays since the installation of these graphic ground meters.

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Wall Chart of Brush Styles—A 12-in. by 16-in. wall chart illustrates the different styles and types of carbon brushes and gives directions for ordering.—Corliss Carbon Co., Bradford, Pa.

Electrical Heating Unit—Literature describes a new type of cartridge electrical resistance unit for industrial heating purposes.—Permway Electric Mfg. Co., 1921 Pine St., St. Louis, Mo.

Speed Transformers—Catalog 111 describes the construction and operation of the Ganschow speed transformers which are made in the planetary, compound and worm gear types as well as a special angle type speed transformer. Numerous illustrations, together with tables of dimensions and ratings, are included. —William Ganschow Co., 1001 W. Washington Blvd., Chicago, Ill.

Electrical Supplies—The 1925-1927 catalog of electrical supplies contains the complete line of equipment and supplies manufactured and distributed by this company. This publication contains 1,200 pages, is profusely illustrated with 4,500 engravings, and lists all new apparatus designed and manufactured in the past two years as well as all the previously established types. Four indices for the convenience of the user have been included in the present catalog. These include a complete subject index, a style number index, an index classified by industries, and a thumb index to the sections.—Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Speed Reducers—Bulletin 38 devotes 48 pages to a description of the Falk herringbone speed reducers, their construction, operation, and advantages of the single-, double- and triple-reduction units. A number of installations are illustrated and dimensions and specifications given for the different reducer units. The Falk-Bibby flexible couplings are also described.—The Falk Corp., Milwaukee, Wis.

Switchboard Instruction Book—The installation, operation and maintenance of switchboards is fully covered in a new 120-page booklet, 87000-E, which is profusely illustrated with photographs, diagrams, tables, formulas and much other varied information of special value to those engaged in the construction, installation or operation of switchboards.—General Electric Co., Schenectady, N. Y.

Composition Fiber Pulley—A circular describes the Petralyke composition fiber pulley for use on severe belt drives such as on drop hammers, motors, generators and other similar service.—The Petralyke Corp., South Milwaukee, Wis.

Flexible Couplings—A circular describes the construction, operation and lubrication of the Fast flexible coupling which consists of spur gear hubs mounted on the ends of each of the two shafts. The gear teeth on these hubs mesh into a floating sleeve with internal gear teeth which surround the two hubs. The shafts and sleeves thus revolve as one unit but allow for lateral and angular play. —The Bartlett-Hayward Co., Scott & McHenry Sts., Baltimore, Md.

Testing Apparatus and Instruments—Circular 410 lists the different Biddle specialties for engineering and laboratory testing.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

Insulating Varnishes and Compounds—A recent 42-page booklet is more than a catalog of Ajax insulating varnishes and compounds in that it discusses, in addition to a description of each type of varnish and compound, the fundamental characteristics of insulating varnishes, gives an insulation guide and the characteristics of each of the baking and air-

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drying varnishes in tabular form. In addition it gives general directions for the use of insulating varnishes, with suggested typical specifications for the varnish treatment of various types of electric motors, describes some common troubles found with insulating varnishes and discusses the method of testing these products.—The Sherwin-Williams Co., Cleveland, Ohio.

Polyphase Motors—Bulletin 38 describes and illustrates the construction of the Type SC, squirrel cage, polyphase induction motor which is constructed in ratings of ¼ to 75 hp. These are constant-speed, continuous-duty, open-rated motors.—Century Electric Co., St. Louis, Mo.

Safety Limit Stop—Bulletin 1040-B describes and illustrates the Youngstown safety limit stop for direct-current motors to prevent such accidents as the over-travel of electrical-driven machinery, particularly the over-hoisting of the hook blocks of electric cranes. This stop is made in three sizes; the No. 1 size is a new design of compact dimensions for use on small- and moderate- capacity cranes where space and mounting are restricted, while Nos. 2 and 3 are used on larger equipment.—The Electric Controller and Mfg. Co., Cleveland, Ohio.

Friction Clutch—Circulars describe the new Hoerl friction clutch and cut-off coupling which is of the cone and lever type with a Raybestos friction lining. Dimensions and directions for ordering are included.—The Wolf Co., Chambersburg, Pa.

Bearings and Bushings—Circulars describe the Ampco bearings, bearing metal and bushings, which are made of an alloy of copper, aluminum and iron. Instructions on how to order, and lists of the dimensions of bushing stock carried, are also given. Other circulars describe the use of this material in acid-resisting castings, chains and hooks for pickling vats, acid valves and other purposes.—American Metal Products Co., 34th Ave. & Burnham St., Milwaukee, Wis.

Standardized Substation—Bulletin 12 describes a new line of standardized steel tower outdoor substations intended for installation by utilities serving, or customers buying, power from high-tension distribution lines.—Delta-Star Electric Co., 2433-2461 Fulton St., Chicago, Ill.

Constant-Speed Polyphase Induction Motors—Bulletin 143 describes the Type L, constant-speed, polyphase induction motors. These are made in ratings from ¼ hp. to 75 hp., two and three phase, 110, 220, 440 and 550 volts. Practically all ratings may be obtained in from two to four speeds.—The Robbins & Myers Co., Springfield, Ohio.

Special Tooth Gears—Circular 265-I and other literature describe the construction and use of the Maag-generated, full-involute tooth gears. These gears are made in spur gear, herringbone or spiral forms and up to 40 ft. in diameter. The Maag tooth has an extra thick base, but is not a stub tooth.—Niles-Bement-Pond Co., 111 Broadway, New York City.

Pneumatic Drills—Recent literature describes a new line of four-cylinder, reversible and non-reversible pneumatic drills, which are equipped with speed governors that automatically prevent racing the drills beyond the safe working speed.—Ingersoll-Rand Co., 11 Broadway, New York City.

Portable Electric Drill—Special bulletin G-30 describes a new improved special ½-in. drill, which is equipped with a universal, ball-bearing motor and is fitted with cord and plug, combination spade handle and breast-plate and three-jaw geared chuck. Other types of electric drills, bench drill stands, bench grinders, post grinders and other tools are also described.—The Standard Electric Tool Co., Cincinnati, Ohio.

Seamless Metal Hose—Bulletin 201-29-A describes a flexible seamless metal hose or flexible pipe which is made by corrugating in spirals either seamless bronze or seamless steel tubing. Fittings are welded on and it is claimed that hose of double structure has been subjected to tests up to 10,000 lb. hydrostatic pressure, and to temperatures as high as 1,000 deg. F.—Chas. Cory & Son, Inc., 183-7 Varick St., New York City.

Special Machinery—An interestingly-illustrated booklet shows some of the facilities of this organization for producing heavy machinery of special design.—Dodge Manufacturing Corp., Mishawaka, Ind.

Publishers Form Corporation to Cover Foreign Markets

ESTABLISHMENT of the Business Publishers' International Corporation to meet more adequately the demand for specialized business publications in the fields of overseas trade and industry has been announced by the McGraw-Hill Company and the United Publishers' Corporation. They jointly will control the new organization.

Three publications already in existence form the nucleus of the new company, which will maintain editorial and business representatives in the important commercial centers abroad. The papers are *Ingenieria Internacional* (*International Engineering*), a McGraw-Hill industrial and engineering monthly circulating in Spain and Latin America; *El Automovil Americano* and *The American Automobile* (*Overseas Edition*) in Australia, New Zealand, South Africa, India, Great Britain, Norway, Denmark, Holland, Belgium, in the Orient and in other territories.

The new corporation is headed by Mason Britton, President, who is a Vice-President of the McGraw-Hill Company. John Abbink, until formation of the new publishing firm, Business Manager of *Ingenieria Internacional*, is Vice-President and General Manager. J. L. Gilbert, who was Business Manager of the two automotive publications, is Vice-President and Secretary. C. A. Musselman, President of the Chilton Class Journal Company, the automotive publications division of the United Publishers' Corporation, is Treasurer.

The Board of Directors includes, in addition to the officers, Charles G. Phillips, President of the United Publishers' Corporation; Malcolm Muir, a Vice-President of the McGraw-Hill Company; Philip S. Smith, Editor of *Ingenieria Internacional;* and George E. Quisenberry, Editor of *El Automovil Americano* and *The American Automobile* (*Overseas Edition*).

Planning a Line-shaft Installation

(*Continued from page 422*)

the best industrial operating practice, generally, and while it may give the lowest first cost of the installation it would probably be better to design the drive to operate at a higher belt speed.

Still another important point to take into account is the proper location of the motor. Obviously it would be an undesirable type of drive to have the motor located at one end of the shaft and the heaviest machine at the other. In such a case, if the machine produced shock loads, the twisting effort on the shaft would be extremely undesirable. It is usually best to place the motor so that about an equal amount of power is taken off on either side of the pulley connected to the motor. A method of doing this graphically, which was also worked out by R. C. Moore, is shown in the illustration at the top of page 422.

One of the advantages of group drive which was not mentioned is that the total horsepower required to operate the group varies from 1/5 to 1/2 of that which is specified for the operation of each individual machine. One illustration of this fact as applied to a special group of small machine tools is shown in the table on page 421.

Still another advantage of using a number of small group drives instead of one large group, is that pulleys of standard bore in the small diameters may be used. Also, it is well to standardize on a few diameters of lineshaft so that a pulley may be transferred from one lineshaft to another. In many plants the storerooms are filled with pulleys with odd-size bores, which will fit only on special shafts. This problem is not so serious, however, where split pulleys and bushings are used.

There are many factors, such as the building construction and placing of the motor or shaft in a definite location, which necessitate a compromise between the best and the necessary. On large installations of power transmission equipment it is advisable to consult with the manufacturer's engineering staff.

EDITOR'S NOTE: Special acknowledgment is made to K. W. Knorr, Engineer and District Sales Manager, Dodge Mfg. Co., Mishawaka, Ind., and to R. C. Moore, Chief Engineer, Chas. A. Schieren Co., New York City, for assistance in the preparation of this article.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

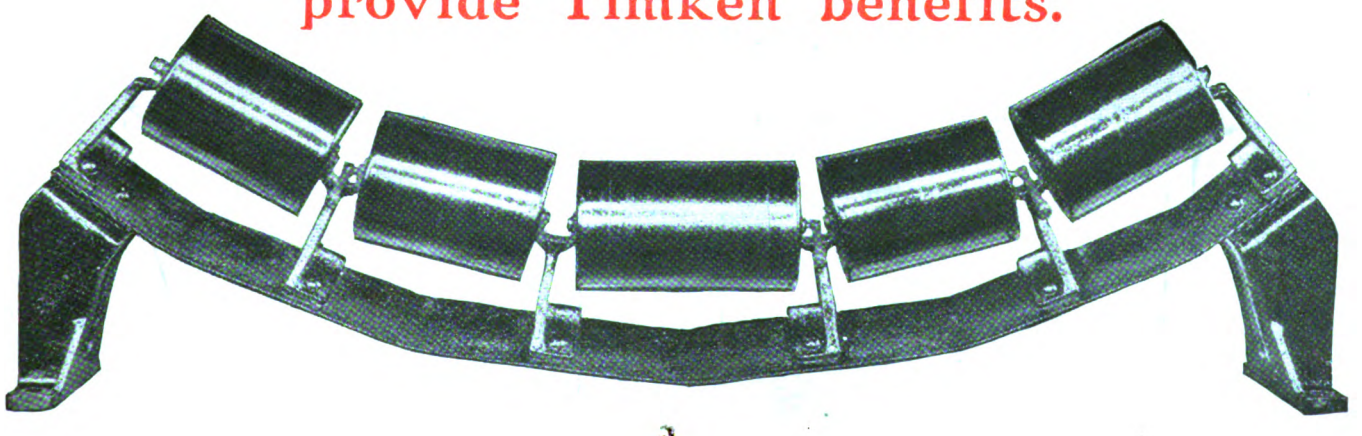
Founded 1882 as
The Electrical Review

October, 1925

McGraw-Hill Co., Inc.
Chicago, Ill.

TIMKEN *Tapered Roller* BEARINGS

Convey on Timken Bearings and you convey with less power, less lubricant, less stoppage. Timken Bearings in simplest mountings, take out the friction, belt-drag, and the chance of flat spots. Timken Bearings carry the thrust loads. Leading Conveyor manufacturers provide Timken benefits.



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Roller Bearing
ALLIS-CHALMERS MOTORS

ALLIS-CHALMERS protects motor users with the strength and accuracy of electric steel frames and distortionless cores. Allis-Chalmers insures motor life with the silver-brazing process on rotor bars, with special baked insulation, with true uniform cooling. And now the advantages of anti-friction bearings are also obtainable in Allis-Chalmers electric motors. The established Allis-Chalmers line is rounded out with Allis-Chalmers induction motors, equipped with Timken Tapered Roller Bearings.

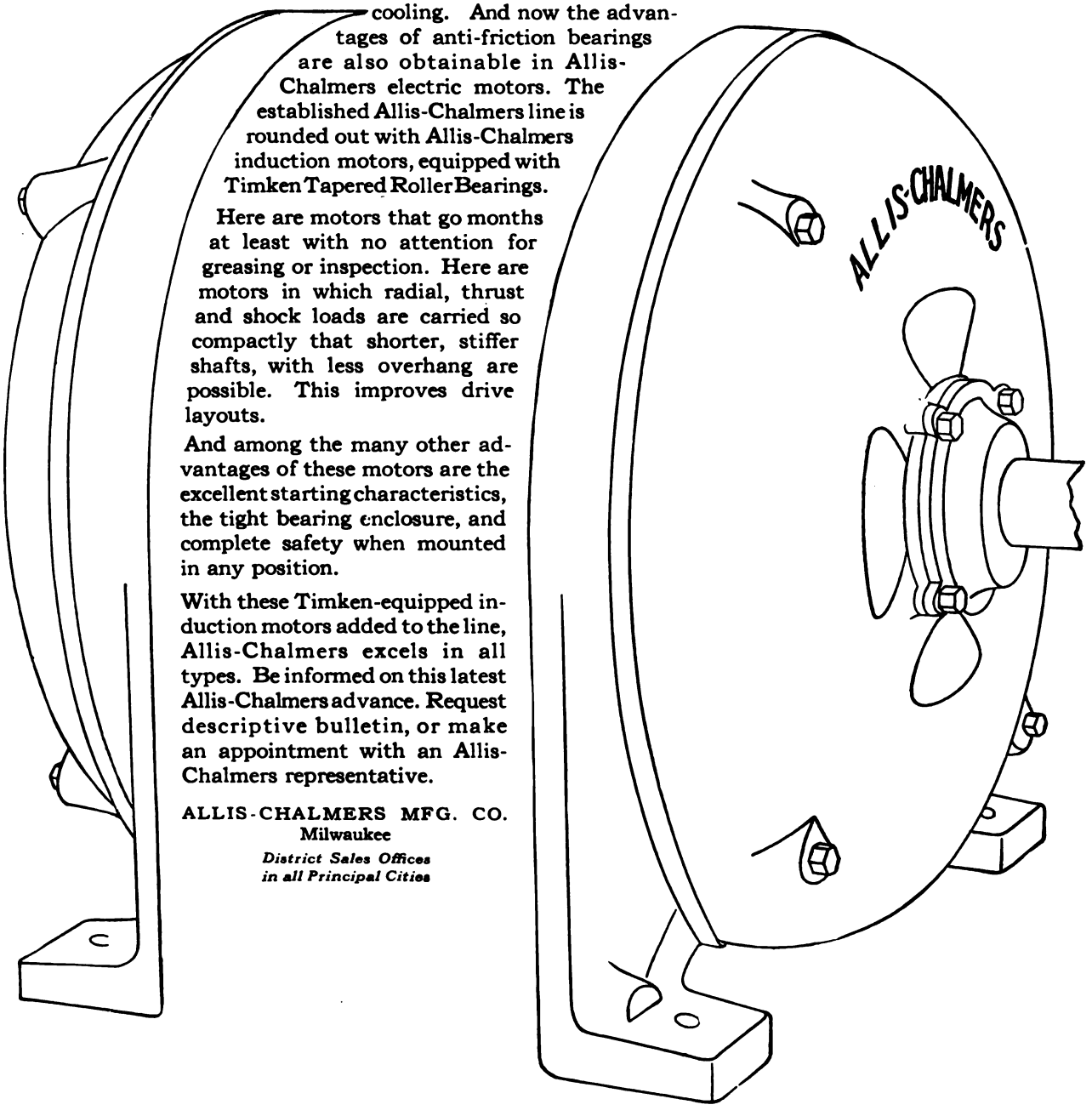
Here are motors that go months at least with no attention for greasing or inspection. Here are motors in which radial, thrust and shock loads are carried so compactly that shorter, stiffer shafts, with less overhang are possible. This improves drive layouts.

And among the many other advantages of these motors are the excellent starting characteristics, the tight bearing enclosure, and complete safety when mounted in any position.

With these Timken-equipped induction motors added to the line, Allis-Chalmers excels in all types. Be informed on this latest Allis-Chalmers advance. Request descriptive bulletin, or make an appointment with an Allis-Chalmers representative.

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Volume 83 Number 10

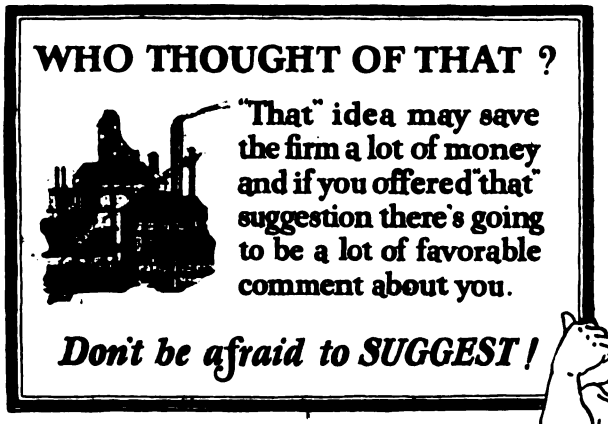
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
JAMES H. McGRAW, *President*
JAMES H. McGRAW, JR., *Vice-Pres.-Treas.*

Chicago, October, 1925

G. A. VAN BRUNT, *Managing Editor*





Here Is a Short Message from Bettendorf, Ia.

That Partly Explains the Efficiency and Teamwork in a Large Industrial Works Organization

NOT long ago I called on the works manager at the Bettendorf Company near Davenport, Iowa, who is "Pete" Reck by name throughout that large institution. At a distance you might imagine that Pete is a hard-boiled individual, for he is large of stature and dignified in carriage, but when you shake his big hand and feel the warmth of his smile, all fear of just what to say vanishes without any effort. If you want to know anything about operations in Bettendorf, Pete can tell you; but he does not hesitate to suggest that you might talk to his superintendents and he makes the way easy by furnishing the required pass to any or all of them.

When you meet these gentlemen, you find them of the same sort as the Boss: just regular fellows who know their stuff. And, somehow, after talking to these men, Bettendorf did not have the cold and indifferent atmosphere that hangs over so many large industrial works, but I did not discover the reason until I returned to Pete's office. There I happened to spy a large poster about 30 in. by 40 in. in colors, that I have tried to reproduce on this page without the coloring. Just ponder over the message on this poster and then realize that the Bettendorf plant covers several acres of ground and employs thousands of men. Any works as large as this one where the management invites suggestions from its men, one and all, can't help but produce men who work with their heads as well as their hands and such men leave the impression of their ability on the apparatus they turn out just as certainly as poor workmen leave their marks in misfits and troubles that come to light in time.

The value of such teamwork among operators as exists at Bettendorf cannot be estimated in dollars and cents, but it takes just such a man as Pete Reck to create and maintain this teamwork. In leaving Bettendorf that night for other points West, I discovered this bit of wisdom in a newspaper:

We were sittin' 'round a'talking, three other guys and me; the Fool I was; the Chap I am; the man I Hope to be. The Fool spoke up in whining voice as fools so often do, and said, "There isn't any room in this big game for you."

The Chap looked on with mournful eye, 'most ready to concede that what the Fool had said to him was just about his speed.

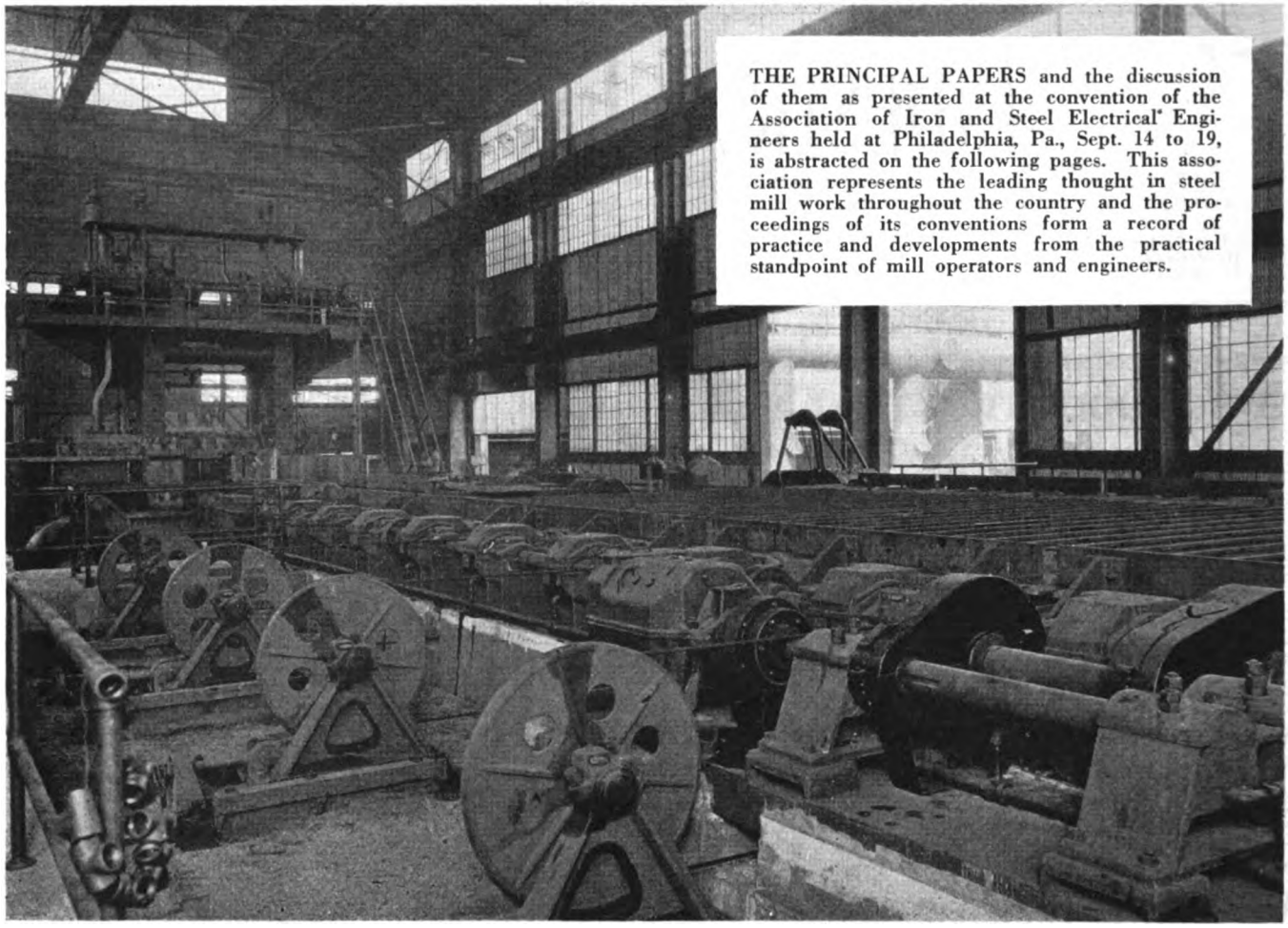
The Man of Hope said smilingly, "That's some philosophy, but what you did before I came don't mean a thing to me. For opportunity is not a ghost that knocks and runs away; she stands within a fellow's reach a dozen times a day. 'Bout all you need is to recall the doctrine of the bold—put on a grin, spit on your hands and grab another hold."

The spirit of this jingle on the part of workmen combined with the open-mindedness of the Bettendorf message on this page, is a sure cure for defeat for an individual or for a company—but in any plant this spirit may grow up and go to seed unless there is a Pete Reck to keep it alive.

When you are anywhere near Bettendorf make it your business to call on Pete—you'll never regret the time spent and you'll learn something about handling men.

Practical Pete

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THE PRINCIPAL PAPERS and the discussion of them as presented at the convention of the Association of Iron and Steel Electrical Engineers held at Philadelphia, Pa., Sept. 14 to 19, is abstracted on the following pages. This association represents the leading thought in steel mill work throughout the country and the proceedings of its conventions form a record of practice and developments from the practical standpoint of mill operators and engineers.

Details of the

Topics Discussed by Steel Men

At the Convention of Association of Iron and Steel Electrical Engineers Held Last Month at Philadelphia, Pa.

MANY problems of vital importance to steel mill operators were discussed at the twentieth annual convention of the Association of Iron and Steel Electrical Engineers held at the Philadelphia Commercial Museum, Philadelphia, Pa., Sept. 14 to 19.

In the main, the papers were free from theoretical viewpoints and dealt with the more practical phases of perplexing steel mill problems that are now being faced or have been successfully worked out during the last two years.

Safety problems as they affect the electrical engineer, the new "frog-leg" winding and the selection and maintenance of oil circuit breakers, were the questions of most import to those attending the convention.

Abstracts of the principal papers are presented in what follows. The main points in the discussion of these papers by different steel mill operators are given in the reports beginning on page 472.

Frog Leg D. C. Armature Windings

By W. H. POWELL AND G. M. ALBRECHT

Engineers, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

IN THE early days when slotted armature cores were first developed, the series or wave winding was used almost exclusively, as machines were all of moderate capacity. As larger sizes were developed this winding was modified by using two or more wave windings on the same armature core and arranging them to operate normally in parallel at the brushes. In some cases, these windings were entirely independent of each other, while in other cases the various circuits closed on each other and were

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known as re-entrant windings. In many cases where a double series winding was used, it was found that after the machine had been in operation for several weeks every alternate bar was burned. If the bars were marked and commutators turned, the machine would again operate successfully for awhile and then burning would occur on every alternate bar, but not always on the same set as before.

After such series windings proved unsatisfactory, the type of winding which was next tried was the parallel or lap winding. With this type of winding the commutating conditions were somewhat poorer than in machines of similar capacity with series-wound armatures and especially on machines with a large number of poles. Some brush studs carried more current than others, with resulting sparking of the brushes. This was found to be due to unequal voltages generated in the parallel circuits and a careful adjustment of the air gaps under the various poles was necessary.

In this type of winding the field strength of only one pair of poles affects one armature circuit, while in the series winding, each circuit is affected by the field strength of all poles, and there could be considerable variation in strength without affecting the balance of the two circuits.

The inequality of voltages generated in the circuits of the parallel or lap winding was remedied by the use of cross connectors located either on the back of the commutator necks or on the back end or U-bend of the armature coil.

At first the number of equalizers used was as few as three per pair of poles. However, in some cases the bars were burned at symmetrical places around the commutator midway between cross-connected bars. An increase in the number of cross connectors was found necessary in order to eliminate the burning of bars.

With machines of the largest capacities, it has been found necessary to cross connect for every armature slot in order to eliminate the burning of bars between cross connectors.

In a new type of winding, which will now be described, there are no external cross connectors at either the front or back end of the armature. Fig. 1 represents a four-pole armature with two windings connected to each commutator bar. The winding represented by dotted lines is a lap winding and that represented by solid lines is a wave winding.

It will be noted that between commutator bar 1_1 and bar 2_1 there is a

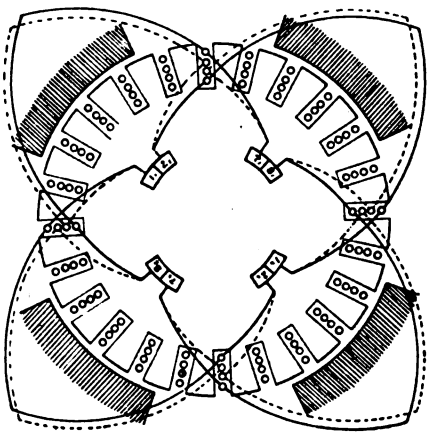


Fig. 1—The frog leg winding is a combination of the lap and wave windings.

This diagram represents a four-pole armature in which are shown the two windings connected to each commutator bar. The winding represented by dotted lines is a lap winding and that represented by a solid line is a wave winding. The combination of these two windings is said to insure perfect equalization of currents, although no external cross connections are used at either the front or back of the armature.

lap winding and between bar 1_1 and bar 2_1 a wave winding. Tracing the coil sides for the lap winding and the wave winding it will be found that on one side they are in the same slot and on the other side they are in slots diametrically opposite and hence both coils are generating the same potential providing the magnetic circuits are of the same strength. Both of these coils are potential-generating, current-carrying circuits, and if made of the same size of conductor, will have the same resistance and generate the same potential and carry the same amount of current.

Tracing the circuits from bar 1_1 it will be noticed that there is a lap coil from bar 1_1 to bar 2_1 and a wave wound coil from bar 1_1 to bar 2_2. Bar 1_1 is thus connected with bar 2_1 and bar 2_2 with equipotential generating coils. Likewise, bar 1_2 is connected with bar 2_2 and bar 2_1 with equipotential generating coils.

The same result is thus obtained as though there were only a lap winding between bar 1_1 and bar 2_1 and between bar 1_2 and bar 2_2, and as though bar 1_1 were cross connected to bar 1_2, and bar 2_1 cross connected to bar 2_2.

Every bar is thereby interconnected with every other equipotential bar without any external cross connectors.

In Fig. 1 the lap coil connected to bars 7_1 and 8_1 occupies the same slot as the wave coil connected to bars 1_1 and 2_2. These two coils, although they must be insulated from each other, can be taped together to form a single coil unit. From the appearance of this coil unit with two coil ends bent toward each other and the other coil ends spread apart, the winding has acquired its name of "frog leg" winding.

The essential difference between a cross-connected armature and a frog leg winding is shown in Fig. 2, which is a portion of a developed lap winding. The caption to this diagram points out the essential differences.

In Fig. 3 is illustrated a machine having eight poles, indicated by letters *A to H*, while the armature has 32 slots in which 64 coils are wound. Of these coils 32 form a simple lap winding and the other 32 form a simple wave winding. The lap winding is indicated by light lines and the wave winding by heavy lines. We thus have a single armature with a single commutator to which both a lap and a wave winding are connected. Brushes may be placed at the places marked with the positive and negative signs. The lap coils occupy the central position in the slot and the wave coils lay in the outermost and innermost positions. This is done for convenience in winding, because wave coil *48* and lap coil *45* for example, can then be readily taped together to form a single coil unit.

In order to show how the lap and wave coils in the windings shown in Fig. 3 are balanced against each other, there is shown in Fig. 4 a portion only of the winding shown in Fig. 3. It will be noticed that the group of four lap coils, *45*, *55*, *56*, *57*, which are connected to commutator segments *1* to *5*, has connected at its terminal, that is, to segments *1* and *5*, the group of four wave coils, *52*, *58*, *59* and *60*. There are, then, between segments *1* and *5*, four lap-wound, voltage-generating, current-carrying, lap-wound coils, with coil sides between poles *A* and *B* and also four wave-wound, voltage-generating, current-carrying coils with coil sides under poles *H*, *G*, *F*, *E*, *D*, *C*, *B* and *A*. If all of the poles are of the same magnetic strength, the voltage generated by each circuit will be equal and as the resistances

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of the circuits are equal, the currents will be equal. If the magnetic strength of the poles is not equal, the current flowing in the two circuits will be proportional to the voltage generated, which in the lap coils is dependent on one pair of poles and in the wave coils dependent upon the average of all the pairs of poles. In Fig. 4 there is also shown the four lap and wave coils between segments *1* and *29*, in which the same conditions obtain as between segments *1* and *5*.

With frog leg windings, every commutator bar is interconnected with every other equal-potential commutator bar without the use of any external cross connectors. This winding can also be used on armatures with duplex, triplex or quadruplex parallel windings, and equally successful results obtained as regards the interconnection of the different circuits.

The maximum capacities of large machines for a given speed, or the maximum speed for a given capacity, can be materially increased by the use of multiplex frog leg windings, as the voltage between adjacent bars can be made equal to approximately one-half of the complete armature coil, and if conditions demand it the voltage may be made one-third, one-fourth or a smaller fraction of one complete coil.

A test was made on an eight-pole generator rated at 1,000 kw., 250 volts, 4,000 amp., 750 r.p.m., 50 per cent overload for two hours. The armature on this generator was wound with a quadruplex, frog leg winding, which means that instead of eight circuits, as in the ordinary winding, there are 32 lap-wound circuits and 32 wave-wound circuits. There are eight circuits in the armature for the lap winding as compared to 64 for the frog leg winding; 500 amp. per circuit at normal load on the lap winding as contrasted with only 62.5 amp. for the frog leg winding; 104 commutator bars for the lap winding, compared to 420 bars for the frog leg, and 32 volts maximum per bar for the lap winding against only 8 volts for the frog leg.

From this data it is apparent that if a simplex lap winding were used for this machine, the current per conductor and the maximum volts per bar would both be too large for successful commutation, especially for swinging overloads. This machine wound with a frog leg winding

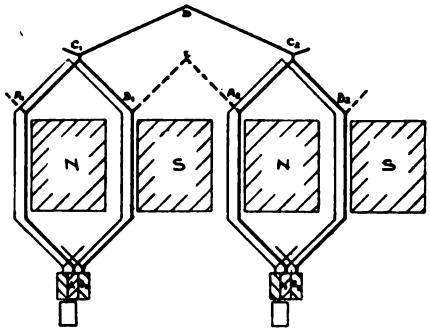


Fig. 2—There is a decided difference between a frog leg winding and a cross-connected armature.

In this diagram is shown a portion of a developed lap winding having two coils with coil sides symmetrically located with respect to two pairs of poles. In the ordinary armature, if cross connected at the back end, a pair of conductors would be fastened to each coil at C_1 and C_2 and after the armature was wound, one of each pair of conductors would be bent toward each other and joined at *D*. Assume that conductors 2_1, B_1, C_1 and 1_2, A_2, C_2 were made of two conductors in parallel, each one-half the width of a single conductor and arranged in the slot one above the other. If one of each of the two parallel conductors is bent at B_1 and A_2 toward the other and joined at *E*, the two coils are cross-connected and the connection, C_1, *D*, C_2 is unnecessary. Furthermore, every coil on the armature, if made in this manner, is cross-connected without requiring any more space on the back end than an armature without external cross connectors. Because of the difficulty of making soldered joints at C_1, *D*, C_2, after the armature is wound, there are used a lap coil, 1_1, A_1, C_1, B_1, 2_1, and a wave coil, 2_1, B_1, *E*, A_2, 1_2 which are insulated from each other and the electrical connection is made at the commutator bar.

was actually tested at 100 per cent overload with black commutation.

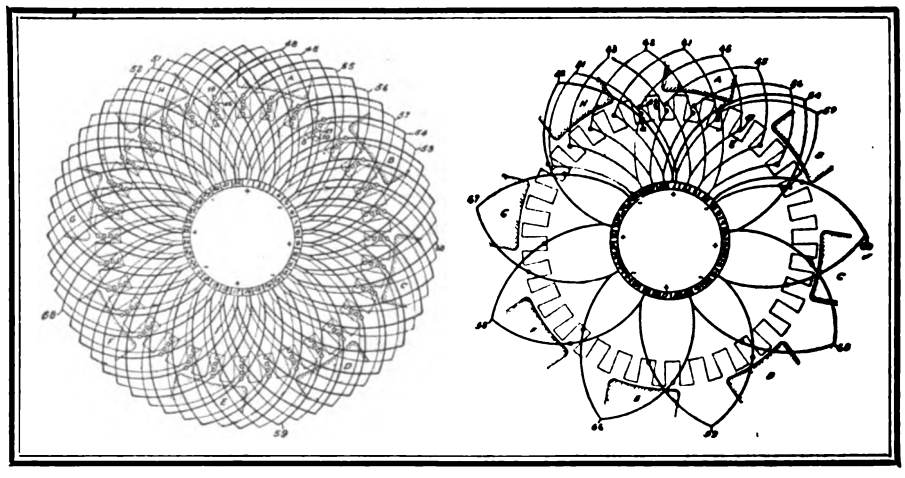
As a test, the shunt coil on one pole was short-circuited and a set of brushes was removed. These brushes were located opposite another pole. Then the load was increased to 5,600 amp. or 40 per cent overload, when the circuit breaker tripped. Under these conditions there was no visible sparking from no-load to overload. It was also found that the brushes could be moved a very considerable distance both ahead and back of the neutral without affecting the commutation. This means that on a single generator the amount of voltage regulation, that is, the compounding, can be varied to suit the particular conditions of operation by moving the brushes and without materially affecting the commutation.

Data was obtained from tests of two machines of the same construction except that one armature, *A*, was wound in the ordinary way with three coils per slot and cross connected at every slot, while the other armature, *B*, was wound with frog leg coils, using no external cross connectors. Machine *A* carried a current of 2,727 amp. for 4 hr. followed by a load of 3,450 amp. for 2 hr. Machine *B* carried a current of 3,600 amp. for 4 hr. followed by 3,850 amp. for 2 hr.

A decrease of 10 deg. in temperature rise in the armature windings in machine *B* was found and is due to the elimination of load losses which are carried by circulating currents in armature conductors and the reduction of any current losses in the conductors due to splitting them into two circuits. A reduction of temperature rise on the commutator of 20 deg. was noted and is due to elimination of short-circuit losses in brushes and improvement in the commutation, which on machine *B* having the frog leg winding was absolutely black on a subsequent test

Figs. 3 and 4—Complete diagram of a frog leg winding for an armature used in a machine having eight poles.

This armature has 32 slots in which are wound 64 coils. Of these coils 32 form a simple lap winding and the other 32 form a simple wave winding. The lap winding is drawn in light lines and the wave winding in heavy lines so that they may be readily distinguished. At the right is shown a portion of this winding so that the circuits may be more easily traced.



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up to 5,000 amp. An increase in temperature of 9 deg. on the interpoles of machine *B* was due to the increase of 11 per cent in current.

On account of the wider commutating zone with black commutation on an armature wound with frog leg coils, there is an easy method of changing the speed regulation of motors by shifting the brushes. This is particularly desirable on motors used for hot strip drives where close speed regulation is necessary.

The frog leg winding has one of the good features of the ordinary series-wound armature in that a field coil can be cut out in case of emergency. This has been done in the smaller wave-wound mill motors where one of the fields has been injured, and it is inadvisable to replace the defective coil immediately. Where this same treatment is applied to a lap-wound armature, violent sparking at the brushes usually results, and in addition there is overheating of the armature conductors and cross connectors if the motor is operated at normal load. In the case of the frog leg winding, a motor with one field coil cut out could be operated at normal load for any reasonable time with but slight increase in heating of the armature.

Selection and Maintenance of Oil Circuit Breakers

By GEORGE A. BURNHAM
Engineering Department, Condit Electrical Mfg. Co., Boston, Mass.

IN the selection of the oil circuit breaker, it is necessary first to study the proposed system on which the application is to be made for the purpose of determining its electrical characteristics. These include the normal working voltage of the system, the continuous carrying capacity of the circuit in question, and the transient current and transient voltage conditions under various circuit combinations. From this may be determined the interrupting requirements, the momentary carrying capacity and the insulation specifications.

Selection should also be influenced by the space requirements, arrangement of terminals, personal safety, fire hazard protection offered by inherent design, features tending toward continuity of service, and the like. For it is these features, after all, which affect the cost of iron and steel indirectly due to fixed charges, insurance rates and interrupted production.

In making a comparison of the design features of circuit breakers consideration should be given to the destructive forces acting on the breaker parts such as the frame, tank, tank fastenings, and insulators. These forces may be mechanical, chemical or electro-magnetic.

Mechanical forces include the effects of internal pressure due to circuit interruptions. At the instant the arcing contacts part, an electric arc is sprung, which displaces the oil. The rate of expansion and volume of gas generated depend, to a large extent, on the energy to be interrupted, the speed of interruption, cooling effect of the oil, and the quality of oil used as an insulating medium. This sudden expansion of the arc or gas bubble below the oil line produces a hammer effect on the sides and bottom of the oil tanks. In this phenomena it is assumed that no explosions take place, and it is the writer's opinion that the pressure wave is of such a shape that no part of the breaker except the tank is subjected to any great stress.

Forces due to ignition or chemical combination of gases thrown off during circuit interruptions, as above mentioned, may be of great magnitude. Explosions may occur either below the oil line during the circuit interruption or in the expansion chamber above the oil line during or after circuit interruption. These may occur in direct sequence, one following the other, as above, or practically simultaneously, in which case the resulting force may be tremendous. Explosions below the oil line produce the "piston effect" by forcing the oil in a body against the breaker top or frame. It may be of sufficient magnitude to cause the oil and gases to be forced from the breaker, or may attain sufficient momentum to fracture breaker tops, insulator fastenings, or breaker mechanisms. Explosions above the oil line in the expansion chamber are, in the opinion of the writer, the major cause of broken switch tops, ruptured tank fastenings and tank deformations of a nature greater than the usual tank bulging.

In the construction of the average circuit breaker, the path of the current in the studs is in parallel planes and at right angles to the plane through the bridging member, thus forming a U-shaped circuit. Such a condition causes electro-magnetic stresses to be set up between the studs and certain reactions are set up in the bridging member, due to the interlinking of the magnetic field of component conducting parts. These forces tend to loosen the insulators and the clamping rings, move the studs in the insulators and force the bridging member from contact with the stationary contact block, even though the breaker be in a closed position. Little, if any, difficulty is experienced below 30,000 amp. but at high current values, say 80,000 to 100,000 amp., the construction and bracing of the main current-carrying members must be extremely rugged to withstand these conditions, and the designer must use every effort to neutralize or balance these forces.

Probably no group of engineers and operators places quite as much emphasis on maintenance as those of the iron and steel industry. Consequently, the circuit breaker design should be such as to provide means whereby inspection and repairs, if necessary, can be easily and quickly made. Opinion is about equally divided among operators regarding the merits of the removable-tank-type breaker compared to the removable-truck-type breaker. Each has certain advantages, depending upon the station construction and arrangement employed.

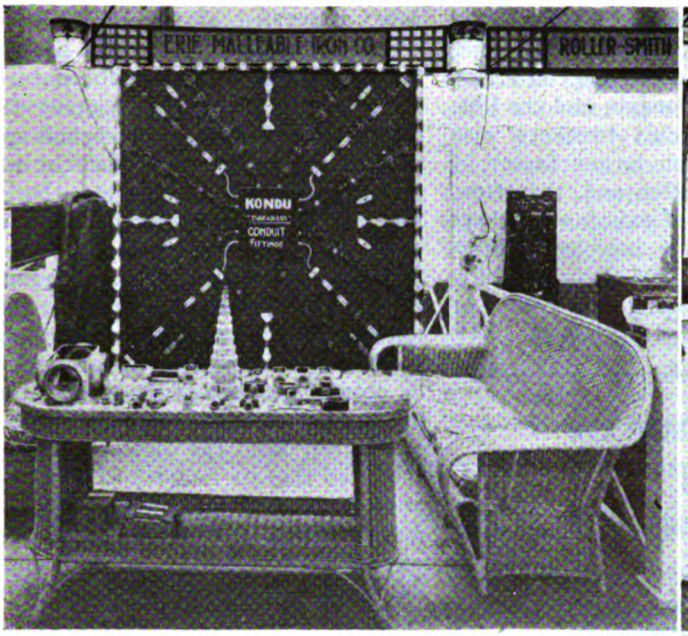
On the question of inspection and adjustment of contacts only, there is really little difference in the time consumed, if tank-lifting facilities are provided for the removable-tank type of breaker. However, if much repair work is necessary, the removable-tank type offers many advantages, both as to time and ease of repair.

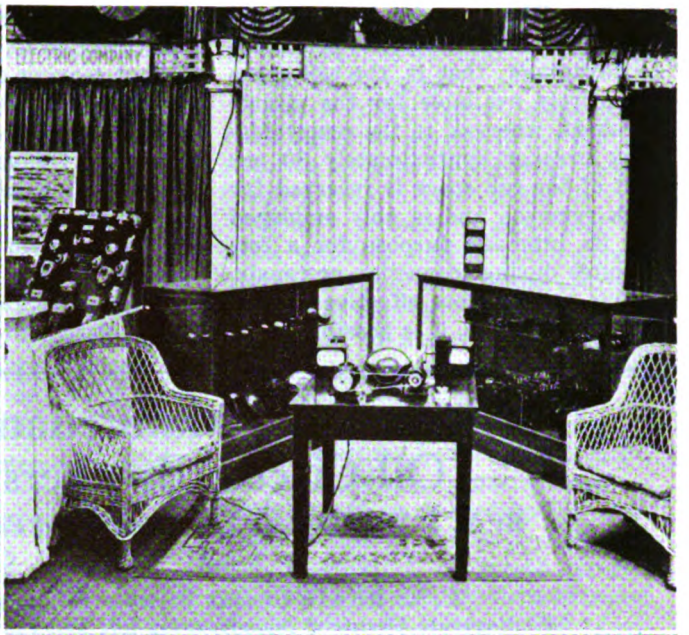
The removable-truck type of breaker has a decided advantage from the viewpoint of cubic-foot-per-ampere of interrupting capacity. Ten years ago the average cubic-foot-per-ampere interrupting capacity for popular removable-tank type, 15,000-volt, moderate interrupting capacity devices was approximately 0.01. Today, it is approximately

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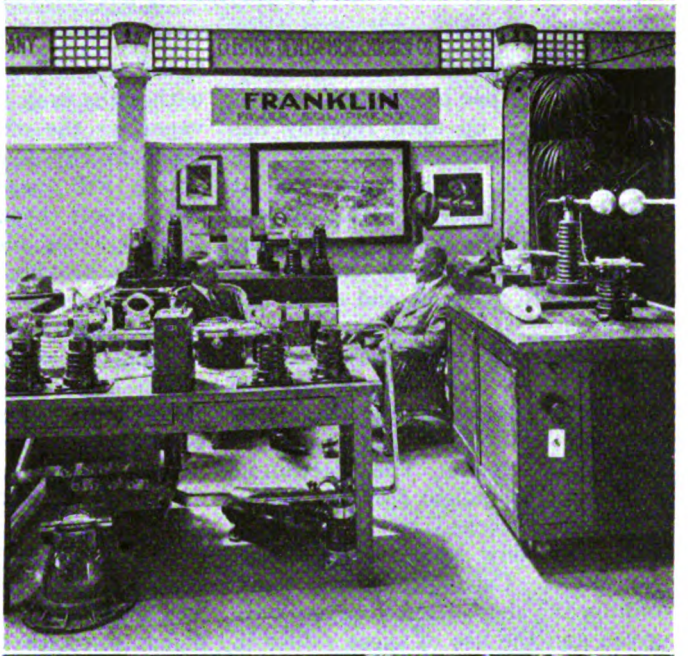




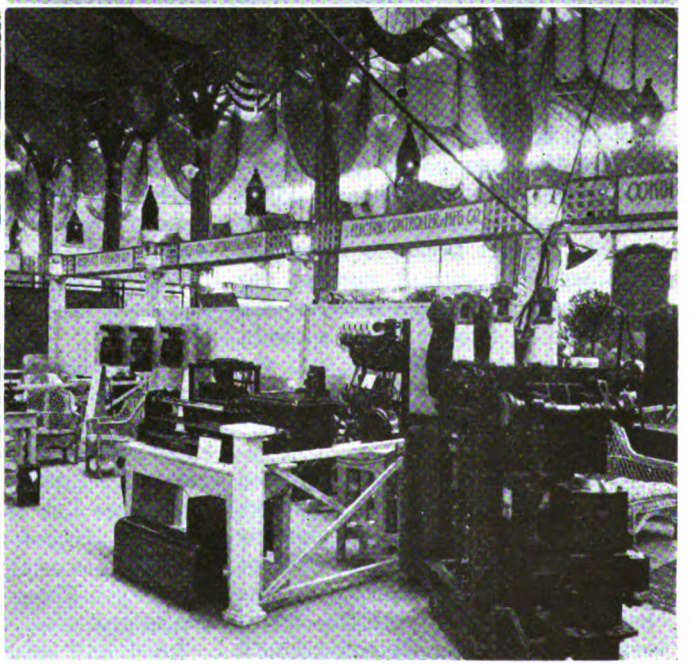
The Steel Mill Equipment Display

At Philadelphia Convention of Association of Iron and Steel Electrical Engineers

The exposition of recently developed equipment for steel mill use is shown from several different angles in the illustrations on these two pages. Nearly one hundred firms displayed a wide variety of apparatus ranging from fuses to massive oil switches, and from conduit fittings to motors and control. This exposition was held at the Philadelphia Commercial Museum at which place the sessions of the convention also were held.







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0.003. The removable-truck-type breaker utilizes the entire cell space to advantage; that is, the cell space is entirely available for the circuit breakers, whereas, in the removable-tank breaker approximately 30 per cent of the cell space is reserved for tank removal, and is only employed for its intended purpose for a few minutes during inspection or repair.

Due to this more effective utilization of cell space, it is possible to increase the interrupting capacity of older installations about eight times without tearing down the cell structure, bus compartments and the like. Present day circuit breakers also have a very much larger factor of safety for insulation and, therefore, the replacement of existing breakers not only provides increased interrupting capacity, but also materially increases the factor of safety of the insulation of a system.

Selection and Maintenance of Oil Circuit Breakers

By M. J. WOHLGEMUTH, *Switchboard Engineer*
and
E. K. READ, *Circuit Breaker Engineer*
Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

THE subject of switching equipment for use in steel mill service is one which up until recently has not received from steel mill electrical engineers the consideration that it merits. It is only within recent times, due to the development of the steel mill industry, that this subject has come to the fore and demanded attention.

In this paper the authors trace the growth of an imaginary steel plant and show the necessary alterations required in the switching equipment due to this growth. The selection of switching equipment for this installation is governed by the current that may flow under short-circuit conditions. Calculations for determining the short-circuit currents are given and the use of these values in selecting the circuit breakers is explained.

It is common practice to relay the various circuit breakers so that the fault can be eliminated from the system by the opening of the fewest and closest circuit breakers. This selective action sometimes requires that the circuit breakers carry the sustained short-circuit current for periods ranging from a fraction of a second up to two or three seconds. It is, therefore, important that the circuit breaker be able to carry the sustained short-circuit for a definite period of time.

After the relays have functioned to trip the circuit breaker, it is necessary that the circuit breaker be capable of interrupting the current that may be in the circuit. In the opening of a short-circuit, the circuit breaker must have sufficient strength to withstand the pressure generated within the tank by the arcing which vaporizes the oil. Anything which tends to cut down the time of the arcing will increase the ability of the circuit breaker by the same amount. An adequate head of oil must be provided over the point of arcing to insure that the gases are cooled sufficiently by their passage through the oil to prevent their ignition after they arrive above the surface. The main contacts should be adequately protected by auxiliary arcing contacts to prevent burning. The contacts which take the arcing should be renewable so that a minimum amount of time will be consumed in renewals and maintenance. The entire structure should have sufficient strength so that oil and gas will not be expelled in objectionable quantities during the operation. The design should be such that the oil and gas which are expelled will not be ignited outside of the circuit breaker.

The design of the insulating details of the circuit breaker is merely a matter of providing sufficient distances to ground through the air and over the surface of the insulation.

The design problem of providing sufficient conducting material so that the circuit breaker will carry its rated current without overheating, is not very difficult. Present day knowledge has rather definitely settled the amount of copper and conducting material that is necessary to carry a given current at a given frequency.

Steel mill service is about as severe a service as is required of switching equipment. The air is filled with dust of a metallic nature and gases which have a seriously deteriorating effect upon electrical apparatus. Apparatus intended for application in steel mills should, therefore, be more rugged and have a wider margin of safety than that for ordinary service. Extra ruggedness is usually obtained by using the best apparatus available upon the market. Extra margin of safety can be obtained by specifying apparatus of the next class to that which would just barely meet the service. On account of the air conditions in steel mills, it is now fairly well standardized practice to install apparatus with a voltage rating of at least double that of the circuit to which it is applied.

It is usual to supply, especially on important circuits, apparatus of a heavier current-carrying capacity than that which is just large enough.

Switching equipment for steel mill use should be kept in the very best possible condition. No opportunities for inspection should be permitted to pass unused. A hurried inspection, if that is all that is possible in the time available, may detect a condition that is very easily remedied at the moment.

A certain amount of inspection of the apparatus may be made while the latter is in service. It is possible to observe the operation of the circuit breakers and obtain a fair idea of their condition. The external mechanism can be looked over, while keeping at a safe distance, for conditions which might later cause an outage if not corrected. The general temperature of the apparatus can be observed at a safe distance. Any condition which can not be corrected in a few minutes, or while the apparatus is alive should be noted and the correction made at the first opportunity. A record should be kept of all apparatus, giving the date and degree of inspection. A schedule should be made out giving desirable periods for casual inspection and for thorough inspection. Opportunities should be watched for, so as to make the inspection as close as possible to schedule requirements.

It is now becoming standard practice with most operating companies to make a complete check of the condition of the circuit breaker after a given number of operations. One operating company drops the tank on the circuit breaker, inspects the

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contacts, checks the condition of the oil, and looks over the circuit breaker generally, after each operation under short-circuit conditions. The service record of the apparatus of this customer is unusually good. Another operator gives the circuit breakers similar attention after three automatic operations. This same operator checks the condition of his apparatus completely every six months, whatever its operating record. This operator also gets very good service from his apparatus.

Obviously, the degree of maintenance is determined by the severity of the service. It is recommended that the apparatus be looked over after functioning on a short-circuit. The circuit breaker should be checked after five to ten automatic operations, paying particular attention to the quality of the oil, to see that the arcing within the apparatus has not reduced the insulating quality of the oil, to an undesirable degree. The circuit breaker should be looked over after approximately 50 to 100 operations to see that no parts have become loosened or displaced.

Report of Electric Heat Committee

By GEORGE H. SCHAEFFER, Chairman

Electrical Engineer, Carpenter Steel Co., Reading, Pa.

THE committee believes that the economics of the heating problem should receive more thoughtful consideration. Each application of a heating furnace (of any temperature) . is a special and separate problem. It is influenced by the particular plant conditions and has its own particular duty to perform. Therefore, it is felt that any application requiring the use of a furnace or furnaces should be considered on its own merits, and each application should be carefully analyzed. By this method only can be obtained comparative costs of operation by the use of the most improved equipment using any form of fuel or energy that might deserve favorable consideration. It is not fair to compare the cost of operation using some old type of equipment with the latest improved design using another form of fuel. The field should be covered thoroughly and the cost of production obtained by the use of latest designs using the different types of energy available.

It is an economic error and a setback to the art to install electric equipment if some other form of energy will meet the conditions equally well and at a reduced cost. The committee feels that no one particular form of fuel or energy will meet every furnace problem.

The attitude of the committee is that electric heat can win only on its merits. If it is not a positive gain over any other form of energy, it has no economic justification. The field for electric heat is rapidly growing, particularly for the medium- and low-temperature furnaces.

Electric Heat Treating Applications

By E. A. HURME

Manager, Steel Mill Section, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

THIS report, which includes all processes in the iron and steel industry in which heat is required, without limitations as to temperature, is intended to cover the principal heat treating and miscellaneous applications not classifed under melting furnaces.

Beginning at the melting furnace, let us consider each process in which heat is required in order to determine the possibilities for electrification.

After the ingot comes from the open hearth, or electric furnace, the first process requiring heat is the soaking pit, where the ingots are brought to the proper temperature.

To the Donner Steel Company belongs the credit for the pioneer installation of an electrically-heated soaking pit. This experimental installation was made in March, 1924. (The results obtained with this installation are given on page 471.—EDITOR.)

The next heating process in progressive order is the reheating furnace for rail, structural, sheet-bar mills, etc. To date there have been no installations of electrically-heated reheating furnaces.

Next in order follows a series of finishing processes requiring the application of heat at somewhat lower temperatures. One such is the "pickling" process in sheet and tin mills, which is done in a vat usually heated by steam at a temperature of about 500 deg. F. There is little doubt that in many cases a saving could be made by using an electric steam boiler to supply the heat.

Galvanizing and tinning are done at temperatures below 1,000 deg. F., and could be done satisfactorily by electricity if warranted by the comparative cost of electricity and fuel.

For annealing of sheets an elevator-type furnace, has demonstrated many advantages over the fuel-heated furnaces. Previous to the installation of this furnace, work was placed in heavy annealing boxes which are essential in fuel-fired practice and frequently the weight of annealing boxes in the furnace just about equals the weight of the work.

For bright annealing strip steel an electric furnace equipment was recently installed at the Stanley Works, New Britain, Connecticut, as a test unit to determine the advisability of commercial bright annealing unstripped steel.

Another use of electric heat in steel mills is the electric roll heater. Electric heaters are now used in some twenty different plants rolling nickel, monel, full finished sheets, black sheets and tin plate.

In the production of rough castings, heat is required in the following processes at the temperatures indicated:

(1) Core baking .....450-700 deg. F.
(2) Sand drying.....450-700 deg. F.
(3) Pattern heating..... 700 deg. F.

Electricity has been successfully applied to all of the above processes.

After the rolling or casting processes outlined above, a surprising amount of iron and steel products undergo heat-treating processes to give them the physical properties necessary for their use.

All metalworking plants have occasion to heat-treat dies and miscellaneous tools used in the manufacture of virtually all products. It was formerly general practice to use either gas- or oil-fired furnaces for the heat treatment of these tools and spoilage of the latter often occurred through inability to properly control the temperature, distribution of heat, and furnace atmosphere.

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In the electric tool furnace, the units may be so distributed as to give perfectly uniform heat from front to back and the temperature is automatically controlled by instruments of precision, so that uniformly good results are obtained with an unskilled and indifferent class of labor.

The following requirements should be considered in selecting a furnace for heat-treating processes, regardless of whether it is electric or fuel-fired:

(1) It should bring the work uniformly to the desired temperature within the limits of accuracy required. (2) The temperature should be accurately and automatically controlled. (3) It should be the most economical equipment for the job, taking into account all factors which affect the "total over-all cost of production." (4) It should not require highly skilled operators, and be capable of producing the desired results without constant attendance and adjustment. (5) It should stand up under the treatment to be expected in steel mill service.

In comparing electric and fuel-fired furnaces it must be realized that the fuel-fired furnace, as well as the electric furnace, can be made to maintain a uniform temperature. The purpose of the furnace, however, is to produce a uniform product, and not uniform temperature charts, so that proper attention must be given to the design in order to uniformly apply the heat to the product.

The electric furnace differs from the fuel-fired in the manner of the application of heat. Most of the heat transfer in the electric furnace is by radiation; the remainder is by convection.

With the fuel-fired furnace, a large part of the heat is transferred by direct convection from the hot gases circulating about the charge, and some by radiation from walls and burners.

The comparison of furnaces from the standpoint of economy requires that all factors entering into the cost of production be given due thought. It is unfair to the electric furnace to compare it with other types on the basis of energy cost alone.

Elements of total cost of product which are affected by the heat treating furnace are:

(1) Labor. (2) Loss due to rejections. (3) Cost of subsequent operations. (4) Handling of material. (5) Cost of auxiliary equipment. (6) Quality of product. (7) Intangible effects, such as working conditions in furnace rooms. (8) Floor space required, including space for fuel storage tanks, pumping and blowing equipment.

In conclusion, the committee wishes to emphasize the fact that all factors contributing to or affecting the "total over-all cost of production" should be considered in comparing various types of furnaces, bearing in mind the small proportion which the cost of energy for heat treating bears in the complete product.

Electric Melting Furnaces

By J. A. SEEDE

Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

ALTHOUGH the arc and induction types of electric furnaces for melting metal started on an even basis over 25 years ago, the superiority of the arc furnace for the average user has resulted in its occupying a well-established position in the iron and steel industries.

Any furnace for melting holds the molten metal in a hearth made of acid or basic refractory material, which either does or does not carry current. Any furnace in which the current passes through the bottom belongs to the conducting hearth type, and among them, following the Girod furnace, may be listed the Gronwall-Dixon, Snyder, Wile, Nathusius, Greaves-Etchells, Moore, etc.

The Heroult type, one of the earliest of the non-conducting hearth types, still continues to occupy an important position. This type of furnace includes the Heroult, Webb, Booth, Swindell, VomBaur, etc.

Two-voltage operation for steel melting furnaces is now practically universal, investigation indicating that there is a decided saving in power and electrode consumption.

In addition to the increase in capacity of electrical apparatus, other changes have taken place, briefly indicated as follows:

For many years, three single-phase transformers were specified for a three-phase furnace, but with increased knowledge of furnace operation and better transformer construction, thoroughly successful operation is being obtained from three-phase transformers. This is desirable, both from the standpoint of the manufacturer and the user.

With the early types of furnaces, the use of external reactance was unnecessary. With increase in capacity and voltage, additional reactance was necessary to reduce fluctuations at the start of the heat, and it is seldom that any up-to-date two voltage arc furnace equipment is installed without external reactance. For external reactors there is a choice between air and iron core types; at high voltages and low capacities the iron core reactor may have an advantage in cost, while at low voltages and high capacities the reverse is the case.

For ten years following the installation of arc furnaces in this country, automatic electrode regulators were imported from Switzerland. Now two automatic electrode controls are built in this country.

While electric furnaces are tilted by hydraulic and electrical means, the latter method predominates at the present time, either alternating or direct-current, crane-type motors being used with entire success.

Alternating-current motors are used in large smelting furnaces where the fluctuations and resultant electrode movements are small and at infrequent intervals, but for melting furnaces, especially for steel and iron, the best control consistent with a minimum of complications is obtained only by the use of direct current motors.

After many trials and failures the induction furnace, which is essentially a device for producing the highest quality product, has returned to its original design, a single-ring, single-phase type.

In the way of auxiliary apparatus, even small single-phase loads at 50 per cent power factor or thereabouts, require a motor-generator set, and consequently the first cost of the equipment is high. However, the addition of a load of this kind to any plant almost always means a reduction in the rate charge.

Perhaps the biggest advance in electric furnace matters has been a demonstration of the commercial feasibility of melting metals in an ordinary clay graphite or similar crucible, surrounded by an edge-wound copper coil, supplied with power at approximately 500 cycles. This type of Ajax-Northrup high-frequency furnace offers many possibilities in the melting of non-ferrous metals and alloys, and high-grade steel.

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Heating of Ingots by Electricity

By RALPH A. BUTLER

Efficiency Engineer, Donner Steel Co., Inc., Buffalo, N. Y.

ELECTRIC heating of ingots at the plant of the Donner Steel Co., has demonstrated in a practical way that ingots can be successfully heated in a manner that will insure almost ideal performance. In the past much criticism of the blooming mill process has been laid at the door of defective or improper heating of the ingot in the soaking pit. By the use of the electric method of heating, the proper temperatures for heating steel of varying carbon content has been discovered. These limits are so accurate that it is possible to determine within a surprisingly narrow range of temperature, the degree of heat necessary to insure a very satisfactory rolling temperature.

The soaking pit that was constructed at this plant was practically airtight. A layer of coke braize was placed at the bottom, helping to produce a decidedly reducing atmosphere. This practically eliminated the formation of scale and it was only when the ingots were removed from the pit that the scale began to form rapidly. This scale was very thin, never over 3/32-in. thick, and as nearly as it was possible to determine, was considerably under half that produced by gas heating.

Upon rolling, the electrically-heated ingots, after the proper temperature of heating had been determined, broke down ideally. They went through the rolls straight and showed no signs of twisting or bending. In addition they gave evidences of rolling easier than the gas-heated ingots. The reduction in electrical peak load on the mill drive ran up as high as 25 per cent in some cases and averages consistently below the peaks when rolling the gas-heated ingots.

The costs of operation and maintenance of this experimental electric soaking pit were higher than costs of ordinary heating, but there were many extenuating factors. If the trial pit were to be built over, the cost of maintenance would be cut down to at least one-third of the present cost. A pit of a new design based on the experience with the old pit would give results altogether different and certainly more gratifying and conclusive. The average power consumption for heating two ingots of 3.3 gross tons each was 531 kw.-hr. When the pit was working ideally and very hot ingots were charged, a figure as low as 100 kw.-hr. was recorded. These figures can be very materially reduced by a pit of a new design.

Safety and the Electrical Engineer

By JOHN A. OARTEL

Chief of Safety Bureau, Carnegie Steel Co.

I WISH to emphasize a few general principles, which should help both the electrical and safety engineers and bring them closer together in their work. About a year and a half ago I had the privilege of making a safety survey of ten large steel mills, employing from 1,000 to 10,000 men each.

From this survey I learned that it is a good thing for men to get together to discuss common problems. Common problems lead directly to the next thing I learned, which was that the plants where the best co-operation prevailed invariably had the best safety record. Co-operation means that the man in the mill or in the office will help his fellowmen, and where the greatest co-operation prevails, there the greatest success is found.

I recently saw this spirit exemplified to a marked degree in a safety drive in a large steel mill employing 6,500 men. In preparing for the drive the safety director and I visited every department to meet and talk with the department superintendent, the safety committee and groups of employees. I was particularly impressed with the very able manner with which the electrical superintendent handled the matter. He was not satisfied with anything less than complete co-operation with the safety director. It was not enough for him to bring the safety committee, the foreman and the gang leaders to the office to hear the talk—he had his entire force come to the electric shop in groups of 50 or 100. The shop was provided with seats in order to have the men comfortable during the talk. Safety bulletins, signs, and slogans were displayed on the wall. Safety devices used in the electrical department were displayed and their use explained to the men. It was one of the finest examples of co-operation that I have ever seen and I take pleasure in stating that the electrical engineer, whose work I have been describing, is the president of this organization, Mr. A. C. Cummins.

On the other hand, I wish to tell you of an incident in a steel mill where the lack of co-operation among several men resulted in a fatality.

Two locomotive engineers working on the 3 to 11 turn, transporting hot billets through a tunnel, discovered that the warning whistle at one end of the tunnel was not working. The electrician was called and made an investigation but could find nothing wrong. He asked one of the engineers to make sure on his next trip that the switch at the other end of the tunnel was all right. At 11:00 p.m., two other engineers came on the job. One of these noted on his first trip to the tunnel that the whistle did not work. He called this to the attention of the electrician then on duty.

At 7 a. m. the turn came to an end. The foreman had given the whistle no further thought; the engineer left the job without advising the man who relieved him that the whistle was not operating; and the electrician also left the job without repairing it or reporting it to the night electrical foreman. About 45 min. later one locomotive was near the end of the tunnel when another locomotive made the first trip through for that turn . The crew were depending on the whistle for warning and as the whistle did not blow they assumed everything was all right. There was a violent collision between the two engines and a man was instantly killed.

During the course of the meeting that I have previously mentioned, Mr. Cummins said to me: "I am trying to instill the thought of service into the minds of my men. I am telling them that they are the service department of the plant. I am trying to get them to understand that the continuous and successful operation of a plant depends upon the character of the work they do." I think that if the electrical men here could take home the thought that their work is indeed a service to the entire plant and if they could spread this among their men, this convention would indeed accomplish something worth while.

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Main Points in the Discussion at Philadelphia Convention

THE need of education and co-operation among workmen, foremen, and department heads, for promoting personal safety were the keynotes struck on the first day of the convention which was given over to the newly formed Safety Division of the Association. In opening the convention, A. C. Cummins, president of the Association, stated that the need for this Safety Division arose from the rapid growth of steel mill electrification which has brought up new problems of personal safety. The safety engineer is experienced in delving into the mental causes of accidents but he is less familiar with the electrical and mechanical elements involved in steel mill electrical accidents. The opposite is true of the electrical engineer. Hence, Mr. Cummins said, cooperation between these two men should bring about accident reduction. The Safety Division has been formed to bring these two men together and enable them to talk over their problems.

No engineer can afford to install a machine that is a menace to personal safety, was a point stressed by L. H. Burnett, assistant to the president of the Carnegie Steel Co. He, as well as C. L. Baker, head of the Safety Department of Cambria Works, Bethlehem Steel Co., said that most plants are well equipped with safeguards—that what is now needed is education of the workmen to think and act safety.

In this connection, W. S. Hall, Electrical Engineer, South Works, Illinois Steel Co., said that 90 per cent of the accidents that now occur in his company are the fault of the individual workman. Although his company has spent a great deal of money for safety devices, which have greatly reduced accidents, yet accidents still occur. Hence his suggestion is that the first year's work of the Safety Division be centered on education of the workmen rather than on a study of protective devices.

In discussing the relationship between the Metals Section of the National Safety Council and the Safety Division of the Association of Iron and Steel Electrical Engineers, Henry A. Renninger, vice-president of the National Safety Council and assistant to the president of the Lehigh Portland Cement Co., said, "The Metals Section of the National Safety Council is one of the largest and strongest industrial sections of the council and has covered a great field, but I realize that the steel industry is a large proposition with many sides that it has not been able to cover. I refer particularly to the electrical problem, which is the most important we have to deal with at present. Practically all of the new plants and many of the old are becoming electrified and it is a case of readjusting and educating the men to the hazards of electrical equipment. The electrical engineer has his particular problems, while the safety engineer has his; they cover a wide field and they must work hand in hand, and through daily contact and conference cooperate with each other in the fullest sense of the word."

How the electrical and safety engineers can be mutually helpful was the subject of a paper presented at this session, by John A. Oartel, Chief of Safety Bureau, Carnegie Steel Co. It is abstracted on page 471 of this issue.

Frog-leg Windings for Armatures of Direct-Current Multipolar Generators and Motors—In discussing this paper (abstracted on page 462), which was presented by W. H. Powell and G. M. Albrecht of the Engineering Department of the Allis-Chalmers Manufacturing Co., Mr. Cummins asked whether or not the four layers of coils required by the frog-leg winding, did not limit the ventilation of the motor, thereby increasing the heating. In reply, Mr. Powell said that slightly deeper slots are used on this type of winding which give more space for radiation. He also pointed out that the test data given in his paper showed that an armature having a frog-leg winding ran 10 deg. cooler than a similar armature wound with the ordinary cross connected winding and which was carrying a lighter load.

The question was asked as to whether or not the equalizing current passing through the load coils in the frog-leg winding did not cause extra heating which would not be present if it were taken through the equalizers of a cross connected winding. Mr. Powell replied that the path of the equalizing current was through the load coils of the cross connected winding the same as in the case of the frog-leg winding; hence both windings had equal heating in so far as this point was concerned.

Mr. Cummins also asked whether the frog-leg winding was likely to reduce the initial cost of the machine. In reply, Mr. Powell said that this winding reduced the so-called load losses such as eddy current losses in the conductors, heating of the commutator from short circuit losses in the brushes, and imperfect commutation. This means that less energy is dissipated in heat and therefore the machine is more efficient and consequently could be made smaller thereby saving material. On the other hand the manufacturing cost of this new type of winding is somewhat higher.

R. S. Shoemaker, Superintendent of Maintenance, American Rolling Mill Co., asked if making repairs to this winding were not harder due to the double coil span, which is characteristic of the frog-leg winding. Mr. Powell said that it does take longer to get at the coil in making a repair, however, there are no cross connectors to take care of and trouble may occur in the cross connectors as well as in the winding. Making a total rewind job, he said, would be as easy as with the usual type of winding.

F. W. Cramer, Asst. Electrical Engineer, Johnstown Plant, Bethlehem Steel Co., pointed out that line voltage exists between adjacent conductors in the same slot and asked what provision was made for taking care of this factor. Mr. Powell stated that each individual coil of a winding unit or frog-leg coil was insulated for line voltage. This means that the slots must be somewhat deeper to take the additional insulation required. Mr. Cramer also said that his company was making an installation of twelve machines having the frog-leg winding and would soon be in a position to obtain information regarding the operation of this winding in steel mill service.

David Hall of the Westinghouse Electric & Manufacturing Co. took exception to the statement that cross connectors are troublesome. He

(*Please turn to page 505*)

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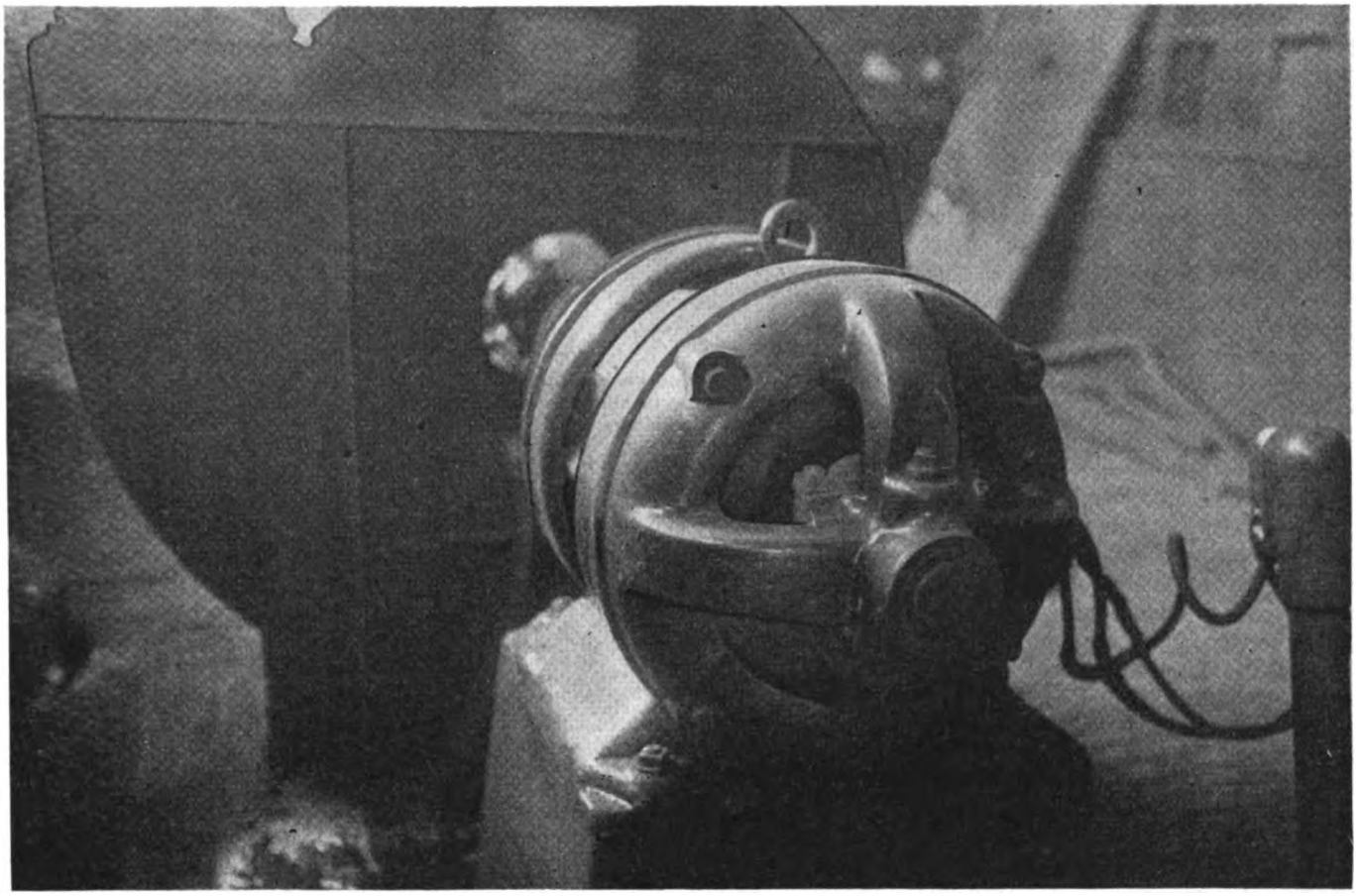


Fig. 1—Trouble from oil-throwing was experienced with the bearings of this high-speed motor, which drives a fan.

It was necessary to rewind this motor about once every eight months until the improved type of sleeve bearing was used. The motor is rated at 25 hp. and drives a booster fan at 1,800 r.p.m. which forces powdered-coal fuel into sheet mill furnaces. The external construction of this bearing may be observed in this illustration, while the internal details are shown in Fig. 2.

Results Obtained Through the

Use of an Improved Type of Sleeve Bearing

Together With the Operating Conditions That Were Encountered Before and After Making Several Installations in a Large Steel Plant

By J. S. MURRAY

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WOULD YOU like to oil your motor bearings only once in a year and a half? In an article, "Ways to Cure Sleeve Bearing Troubles," published in Industrial Engineer, March, 1924, R. Pruger told how certain sleeve bearing troubles were corrected in a new type of bearing housing. In this article Mr. Murray gives the results of his experience with this type of bearing on motors used in steel mill service. Among other advantages the low maintenance is shown by the fact that the first installation has had no oil added to it during a year and a half of operation, and there have been no winding troubles.

THE attention of many operating engineers seems to be directed to the troubles that have been encountered with the sleeve type of bearings in use on general-purpose motors, and on steel mill motors in particular. Those who have had operating experience know only too well that a majority of all winding failures can be attributed to oil being deposited on the winding. This oil comes from the sleeve bearings by leaking out around the shaft and gradually creeping into the windings, which become soaked with oil and covered with dirt.

Oil leakage may be traced to a variety of sources. It may be due to carelessness in splashing oil on the housing when oiling the motor; it may be due to oiling while the motor is in operation, which is very poor practice and usually results in an oil overflow when the motor comes to rest.

On the other hand, we find the construction of some types of sleeve bearings such that an unbalanced air pressure appears to be set up which sucks the oil out of the bearing into the motor winding. In some high-speed motors the oil rings cause considerable agitation of the oil and as the temperature tends to vaporize some of the oil, any air passing through the housing will pick up some of this vapor and deposit it

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upon the windings. Also, if air passes through the bearing it is carrying dirt into it which increases the bearing wear. Another cause of oil leakage is faulty location of the oil grooves in the bearing.

The fundamental cure for this trouble would appear to lie either in providing a sleeve bearing that would retain the oil or grease in the bearing, thus not only preventing damage to the windings but also insuring long life of bearings and necessitating but little attention, or by providing a bearing of the roller or ball type where the probability of excess lubrication and leaking of same into the motor is slight.

During the past few years, a great deal of field data has been submitted by various operating engineers relating to their experiences with ball and roller bearings, and pointing out the unsatisfactory features of the sleeve bearings. This has been a material factor in stimulating a general interest in the improvement of bearings by motor manufacturers.

Some of the improvements that have been made are described in a very excellent article by R. Pruger of the Westinghouse Electric & Manufacturing Company. This article appeared in the March, 1924, issue of INDUSTRIAL ENGINEER. In brief, this bearing is so constructed that the air pressures within the bearing housing are balanced, thereby preventing air from getting in and oil from leaking out. A cross-section of this bearing and housing is shown in Fig. 2. As can be seen, the bearing shell itself has not been changed in design, but the housing has been altered. The cover *D* that closes the opening through which the oil ring is admitted, has been placed on the inside end of the housing instead of the outside. This location permits bolting down the cover and compressing the packing under it. For the purpose of inspecting the oil ring, a large pipe plug *L* has been placed on the outside end of the housing. This plug can easily be removed and put back in place, air-tight. The dowel pin, *E*, which is ordinarily inserted from the outside wall of the housing to keep the bearing from turning, has been placed on the inside of the housing and any oil-pumping is thus rendered harmless, since it is inside the housing itself. To further guard against leakage, tapped holes have been eliminated wherever possible and the drain plug usually found at the bottom of the housing has been removed.

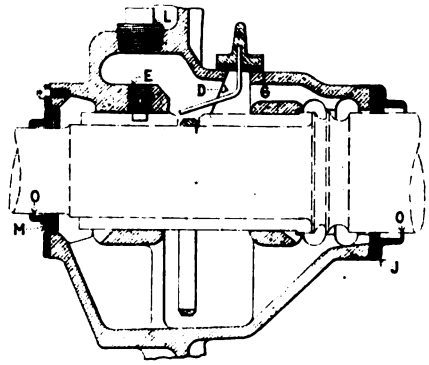


Fig. 2—Cross-section view showing improvements made in sleeve bearing to prevent oil leakage.

The bypass for air at *G* prevents unbalanced air pressures within the bearing. Oil leakage from careless filling is overcome by the inner bearing cap at *J*. Slopping out oil at the oil ring slot, *D*, is prevented by the cast cover bolted down against a shellacked felt gasket. The oil ring slot *D* and oiling hole *L* are tightly closed as shown, which, in addition to felt washer, *M*, seal housing against ingress of air and thus prevent currents of air passing through the housing. Oil leakage to the exterior of the housing cannot take place through the steady-pin hole *E*. Bearing cap lip *O* eliminates oil spray from ventilating air by preventing its escape at housing along shaft.

To eliminate throwing of oil a conical collar forming a seal and acting as an oil thrower has been placed on the shaft on the inside of the bearing. For the purpose of dustproofing the housing, soft felt washers are placed at both ends as at *J* and *M* of Fig. 2. In very dirty places a double chamber cap can also be provided at the outside end of the bearing housing.

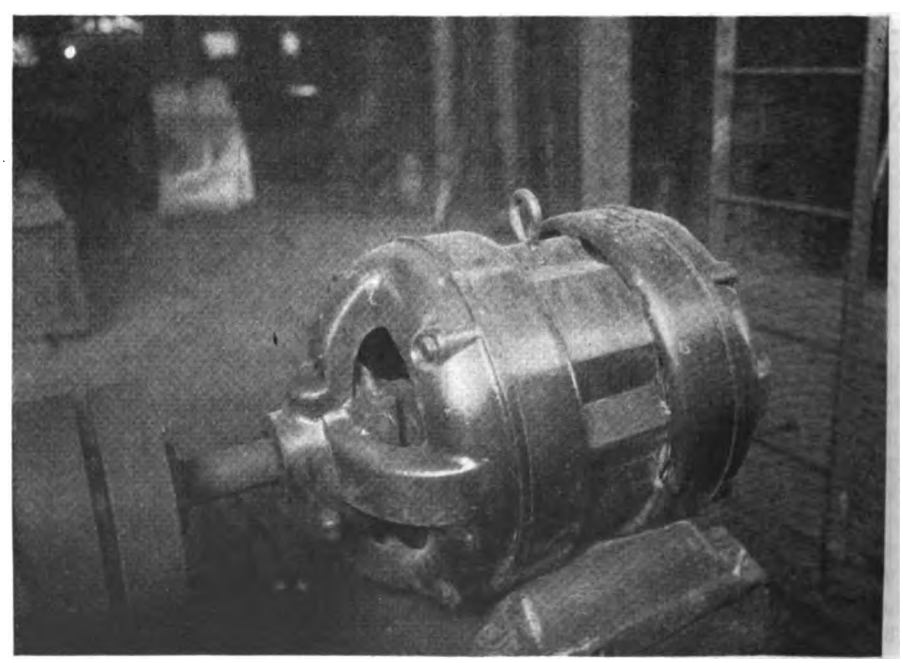
We had had considerable trouble with the throwing of oil on motors running at speeds of 1,200 and 1,800 r.p.m. and were much interested in determining what could be done to eliminate such troubles by means of this improved type of sleeve bearing.

In particular, considerable trouble had been experienced from oil-throwing on the motors driving two booster fans. These fans are used for boosting the pressure in the powdered-coal fuel pipes leading to the sheet mill furnaces. Naturally, the motors are required to operate in a very dirty location. They operate 24 hrs. a day. The motors are rated at 25 hp., three phase, 60 cycles, 1,800 r.p.m., 220 volts and are of the squirrel-cage induction type. It was necessary to rewind these motors about once every eight months, due to the failure of insulation from being oil soaked.

Inasmuch as these motors are vital to the continuous operation of the sheet mill, we decided to try a set of the improved type of sleeve bearings on one of them. Accordingly, we obtained two new end brackets which were equipped with the new bearings and installed them on one motor, as shown in Fig. 1. This set was installed Sept. 3, 1923. We were so well pleased with the operation of these bearings that an-

Fig. 3—The bearings on this motor ran a year and a half without the addition of oil.

The shaft on the outside of the bearings is actually rusty while the windings are bone dry. This illustration shows the coupling end of the motor illustrated in Fig. 1.



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other set was installed shortly afterwards on the other booster fan.

Up to the present time no oil has been added to these motors since the date of installation. The shaft on the outside of the bearings is actually rusty, while the windings are bone dry.

In our water treating plant there are two centrifugal pumps which are used for pumping feed water to the boilers of our power plant. The motors driving these two pumps are of the squirrel-cage type and are each rated at 20 hp., 220 volts, 60 cycles, 1,750 r.p.m. The location of the motors is rather clean, but very damp. Shortly after the motors were installed, they started throwing oil. Hence we decided to equip these motors with end brackets having the improved type of sleeve bearing. The motors having these bearings were installed in April, 1924, and have been in continuous operation ever since. They are giving results similar to those just described. This application is illustrated on this page in Figs. 4 and 5.

We have six 7½-hp., 870-r.p.m squirrel-cage motors driving shears. This is rather severe service, for each time the shear makes a cut a heavy load is thrown on the motor, notwithstanding the fact that there is a flywheel on the shear drive and a non-metallic pinion on the motor. Each time a cut is made by the shear, the sudden application of load tends to make the shaft jump, thus forcing out the oil above and below the shaft. Consequently, oil-throwing trouble was encountered even though the motor ran at a relatively low speed.

During a period of three years, three winding failures which could be traced directly to oil, occurred on these six motors. These failures were further complicated by the fact that a semi-closed slot type stator was used, which was wound with single-cotton-covered, enameled wire. Inasmuch as the winding was originally dipped and baked by the manufacturer after being wound, a rather unreasonable expense was incurred in stripping the oil-soaked windings.

The oil troubles on these shear motors have been corrected by using the improved type of sleeve bearing.

Again, considerable trouble from oil was encountered on six 5-hp., 1,800-r.p.m., squirrel-cage motors driving furnace fans. These motors had been in service a year and a half and although no failures had occurred, it was necessary to thoroughly clean them twice during this period. Each cleaning consisted of washing with gasoline, drying and revarnishing. The necessity for this frequent cleaning has been eliminated by the installation of the improved bearing housings for motors.

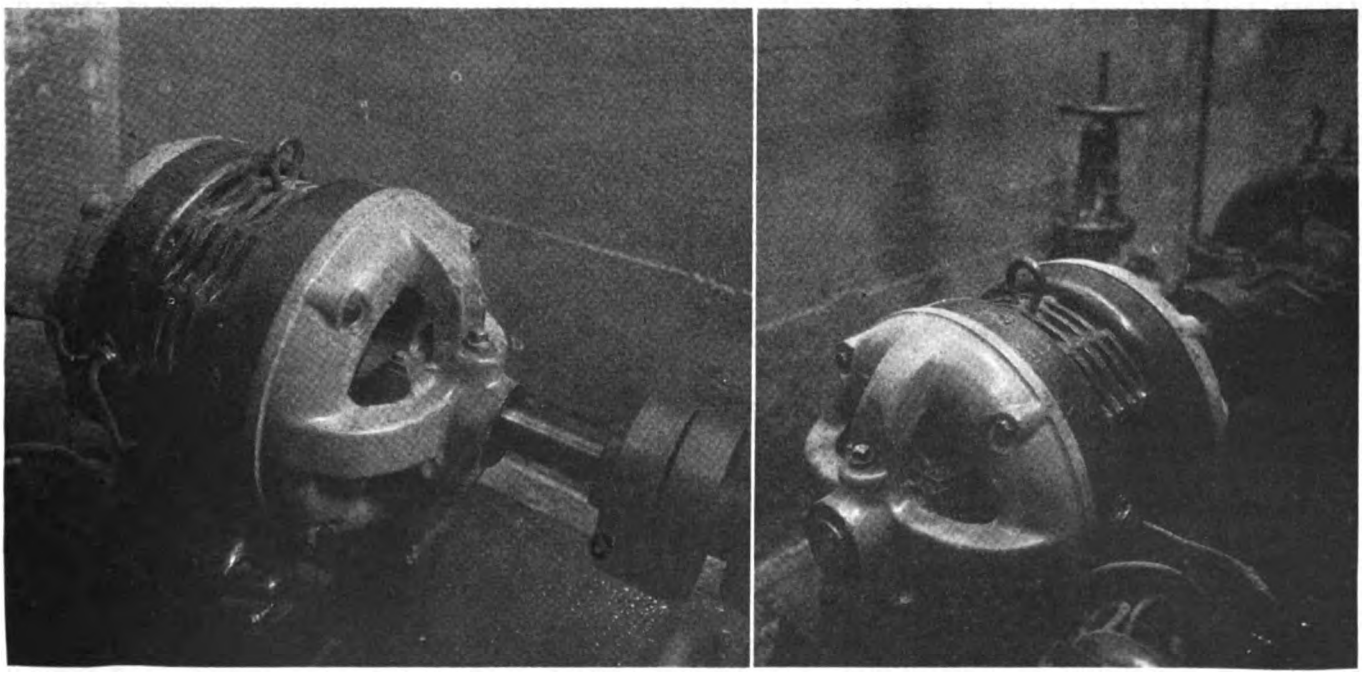
Over a period of three years we had a winding failure on each of two 5-hp., 3,450-r.p.m., squirrel-cage induction motors driving forge blowers. These two failures could be traced directly to oil trouble, which is not surprising considering the high speed of the motor. We have put the improved type of bearing on these two motors and so far the results obtained are highly satisfactory.

We are now equipping with the new bearings, six 5-hp., 1,160-r.p.m., squirrel-cage motors which drive the gas producer grates. These are gear drives and are located in a very dirty atmosphere. Considerable oil trouble has been had from these motors. This is believed to be aggravated somewhat by the fact that the motors are geared to the grate drive. However, we expect these new bearings to eliminate our trouble.

So far these bearings have not only eliminated considerable repair expense from the failure of oil-soaked windings, but have also cut our maintenance cost for cleaning and washing the windings of the motors. The bearings also save considerable oil inasmuch as the oil-throwing is stopped. In fact, it is no longer necessary to have an oiler make regular rounds to the motors equipped with these bearings. In addition to the foregoing there is the reduction in delays due to motor failures.

Figs. 4 and 5—There was considerable oil-throwing on these pump motors before improved bearings were installed.

Improved bearings were installed on these motors in April, 1924, and have been in continuous operation ever since, giving results similar to those obtained with the application shown in Fig. 3.



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Fig. 1—A system of general lighting gives this machine shop a cheerful and stimulating atmosphere.

This lighting system consists of 1,000-watt, clear Mazda lamps in RLM reflectors. The lighting units are spaced 25 ft. in one direction and 30 ft. in the other; the mounting height is 40 ft. The intensity of illumination is 8 foot-candles.

Some Practical Viewpoints on the

Features That Distinguish a Good Lighting System

In an Industrial Plant, Together With a Discussion of the Factors That Must Be Considered When Planning a Lighting Installation According to Modern Standards

By ROY A. PALMER

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MUCH has been written and said concerning better lighting and its benefits in the industries, but there are still many factories which are poorly lighted because of the lack of knowledge as to what good lighting is. Then, too, there are, perhaps, many recently installed lighting systems which measured fully up to modern standards when new, but have fallen below that standard through neglect. This neglect can also be attributed, in part, to the fact that plant executives may not be in a position to judge the quality of the illumination in the plant and therefore when the lighting depreciates or becomes inadequate for the work at hand it remains uncorrected. Those who are responsible for the lighting of the plant should acquaint themselves with the essentials of good lighting, so that they can correctly appraise the adequacy of the illumination. Then the possibility of losses from reduced production, accidents, etc., which are attributable to poor light will be greatly minimized.

A LIGHTING SYSTEM that is fully up to modern standards is not entirely a matter of installing lighting units, wiring and conduit. For the effective utilization of this equipment there must be careful consideration of a number of factors, including the level of illumination required for the work done, selection of lighting units that will, without glare, give a uniform distribution of light with a minimum of shadows, and so on. In this article, which is the second of a series, Mr. Palmer discusses some of these factors and describes the lighting equipment that is available for use under different conditions.

QUALITY OF LIGHT FURNISHED IS IMPORTANT FACTOR

One of the most prolific causes of poor light is glare. Clear, unshaded lamps are the principal sources of glare. Drop cords hung promiscuously about the room are often equipped with unshaded lamps, while some are fitted with flat or tin cone reflectors which are worthless both from the standpoint of protection from glare and from the standpoint of properly directing the light.

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Some Earmarks of a Defective Lighting System

(1) Unshaded or clear lamps, exposing filament.
(2) Lamps suspended by drop cords throughout the room.
(3) Lamps equipped with antiquated reflectors.
(4) Lamps too small in size.
(5) Dirty lamps and reflectors.
(6) Lamps and lighting current of different voltage rating.
(7) Lighting units too far apart.
(8) Dark shadows with sharp outlines.
(9) Gloomy atmosphere in the room.
(10) Lamps mounted at varying heights from the floor.

Where lamps are suspended by drop cords, they are continually in need of adjustment in order to illuminate the work. The result is that the lamps become badly finger-marked and soiled, thus reducing the light output of the lamp and creating an unsightly appearance. Furthermore, considerable time is lost in adjusting the position of the lamp to best suit the illumination requirements. Good illumination is not obtained by haphazard placing of units about the room. It is, therefore, obvious that drop cords spaced and mounted at random are earmarks of a poor lighting system.

Improper reflecting equipment constitutes another of the faults of many factory lighting systems. Antiquated reflectors are still in use in many factories today, notwithstanding the fact that standardized, scientifically-designed reflectors have been available for some time. The reflecting equipment shown in Fig. 2 is now obsolete and has been replaced by the standard RLM dome. Two types of reflectors which preceded the RLM dome are graphically compared with the latter in Fig. 3. As will be seen, the advantages of the older types of reflectors have been retained in the RLM dome, while the objectionable features have been eliminated.

With the wider use of large lamps, the danger from glare increased. The necessity of protecting the eye from undue brightness of the filament was solved by providing a sufficient shielding angle on the reflector and coating the bowl of the lamp with enamel, so as to soften the light from the bright filament. Clear lamps should not be used where the units are mounted less than 20 feet above the floor. In many instances, clear lamps are used in replacing burned-out lamps where the mounting height is less than 20 ft. The brightness of clear lamps at low mounting heights is decidedly objectionable and especial care should be exercised to insure that bowl-enameled lamps are used.

Size of Lamps Replacing Burned-out Units Is Important

In many plants, too little consideration is given to the proper size of lamp. Too often when burned-out lamps are replaced, lamps of the wrong size are substituted. If the new lamp is smaller, than the one it replaces, there will be a decrease in the amount of illumination supplied. Then, too, various sizes of reflectors require specific sizes of lamps. If a lamp of a size other than that called for by a particular size of reflector is used, the efficiency and distribution of light will be affected. This condition exists because each size of reflector is designed for a definite position of the lamp filament when the lamp is in the reflector. Thus, if the lamp is too small for the reflector, the efficiency of the reflector is lowered and the distribution of light is distorted. If the lamp is too large, the lamp will be too low and the filament will not be properly shielded by the reflector. Glare will, ation is given to the proper size of source.

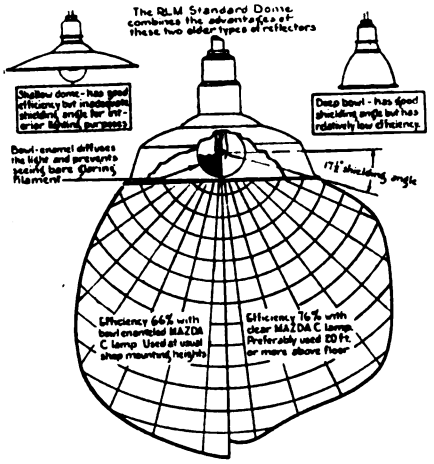


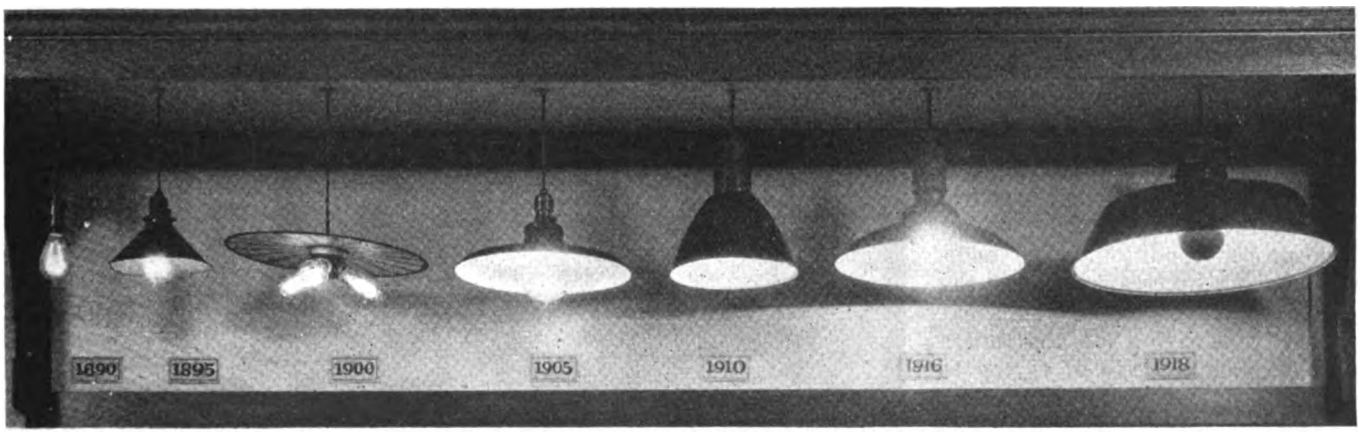
Fig. 3—How the standard RLM dome reflector compares with the shallow dome and deep bowl, two common but older types of reflectors.

The table on page 478 shows the lamp sizes for use with the various sizes of RLM standard dome reflectors. It will be noted that those lamps which have the same light-center length can be used in the same size reflector. To guard against the use of the wrong lamps, it may be well to stencil the proper lamp size on the reflectors.

When lighting units are located promiscuously about the room, the illumination will not be uniform. In some parts of the room the light will be insufficient and heavy shadows will be caused by the predominance

Fig. 2—Here are some examples of lighting equipment that is considered to be obsolete.

The equipment shown is as follows: 1890, bare carbon lamp; 1895, tin cone reflector with carbon lamp; 1900, cluster with mirror reflector, using carbon lamps; 1905, flat cone reflector with tungsten lamp; 1910, bowl reflector with tungsten lamp; 1916, dome-shape reflector (a mean between the flat and bowl types) with gas-filled tungsten lamp; 1918, metal dome reflector and tungsten lamp fitted with metal-cap diffuser.



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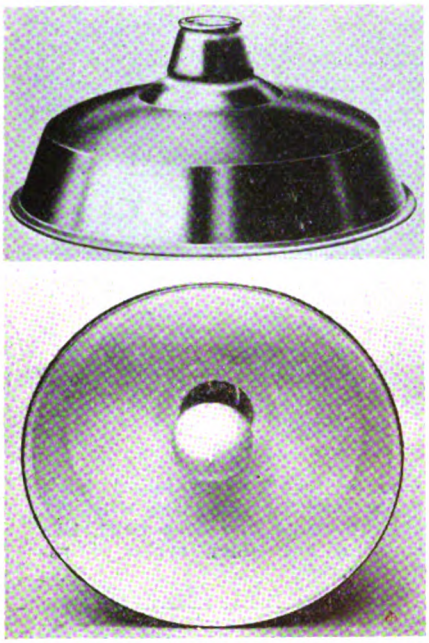


Fig. 5—The RLM standard dome reflector meets most industrial requirements where a direct lighting system is used.

The upper illustration shows the general shape of the RLM standard dome. Below is a bottom view of this reflector equipped with a bowl-enameled lamp. See Fig. 3 for a comparison of the results obtained when bowl-enameled and clear lamps are used.

of light from the well-lighted parts of the room. The units of a general illumination system should not be mounted at different heights from the floor. For the average factory workroom the socket should be about 10 ft. from the floor. In large factory buildings where the ceilings are high and where there are traveling cranes, the mounting height will, of course, have to be higher. Large lamps at relatively large spacing distances will, at high mounting heights, give the desired level of illumination.

The plant executive should keep the foregoing points in mind when he inspects the lighting system in his factory. By so doing he will be able to determine whether or not the illumination is of adequate quantity and quality and can quickly detect the faults that need correction.

Points to Consider When Planning a Lighting System

In many plants, the lighting system is such that it may require complete revamping in order to put it in proper condition. The additional wiring necessary to place the new units properly may be sufficient to justify rewiring of the entire room or plant, instead of trying to utilize the old wiring. Furthermore, the old wire may not be large enough to carry the added load occasioned by more and larger-sized lamps. On the other hand, it may be possible to utilize the existing wiring to the fullest extent without much change. In any event, the planning of a new lighting system will involve careful consideration of a number of factors depending upon conditions in the plant in which the lighting system is to be installed.

The nature of the work performed will largely determine the amount of light necessary. Where the work requires close visual application, a high level of illumination should be provided in order to safeguard the worker's vision and to insure accuracy in his work. Where the nature of the work is rough and the demands in the way of vision and accuracy are not so great, less illumination will suffice. However, the level of illumination in places where rough work is done, such as in shipping rooms, foundries, etc., is usually far below what it should be.

The three general systems of lighting—direct, indirect and semi-indirect—distribute the light by means of reflecting equipment which has become fairly well standardized. For most factory work, direct lighting systems using the RLM metal reflector have found great favor. There are few industries where dirt and dust preclude the use of indirect or semi-direct systems, which depend upon the reflecting power of the walls and ceilings. In offices, employes' rest rooms, conference rooms, lunchrooms and the like, these systems may prove to be very desirable. Some of the lighting equipment available for special applications is shown in Fig. 4.

When the lighting of the factory is under consideration, most of the attention is usually centered upon

(*Please turn to page 506*)

Lamp Sizes for RLM Dome Reflectors

Diameter of Reflector	Proper Mazda Lamp
12 in.	75-watt
14 in.	100-, 150-watt
16 in.	200-watt
18 in.	300-, 500-watt
20 in.	750-, 1,000-watt

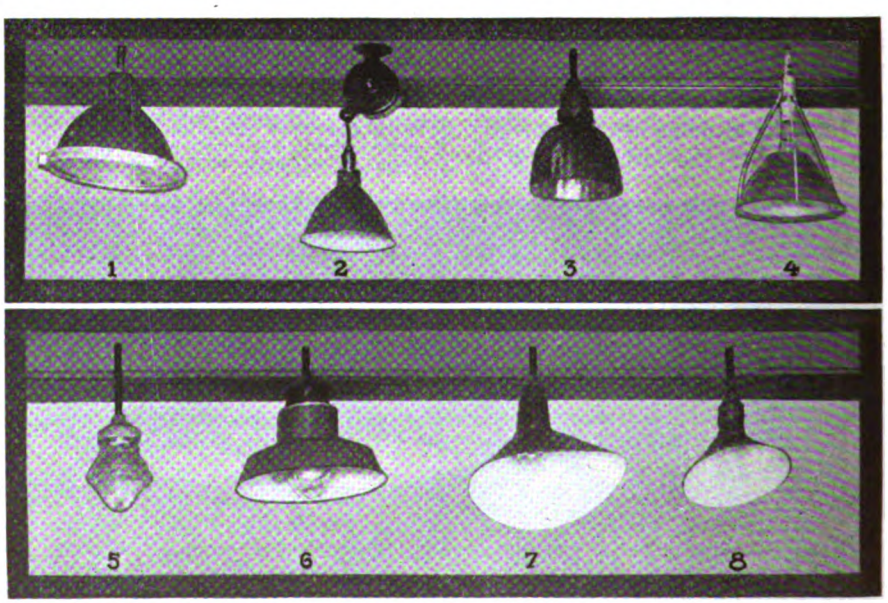
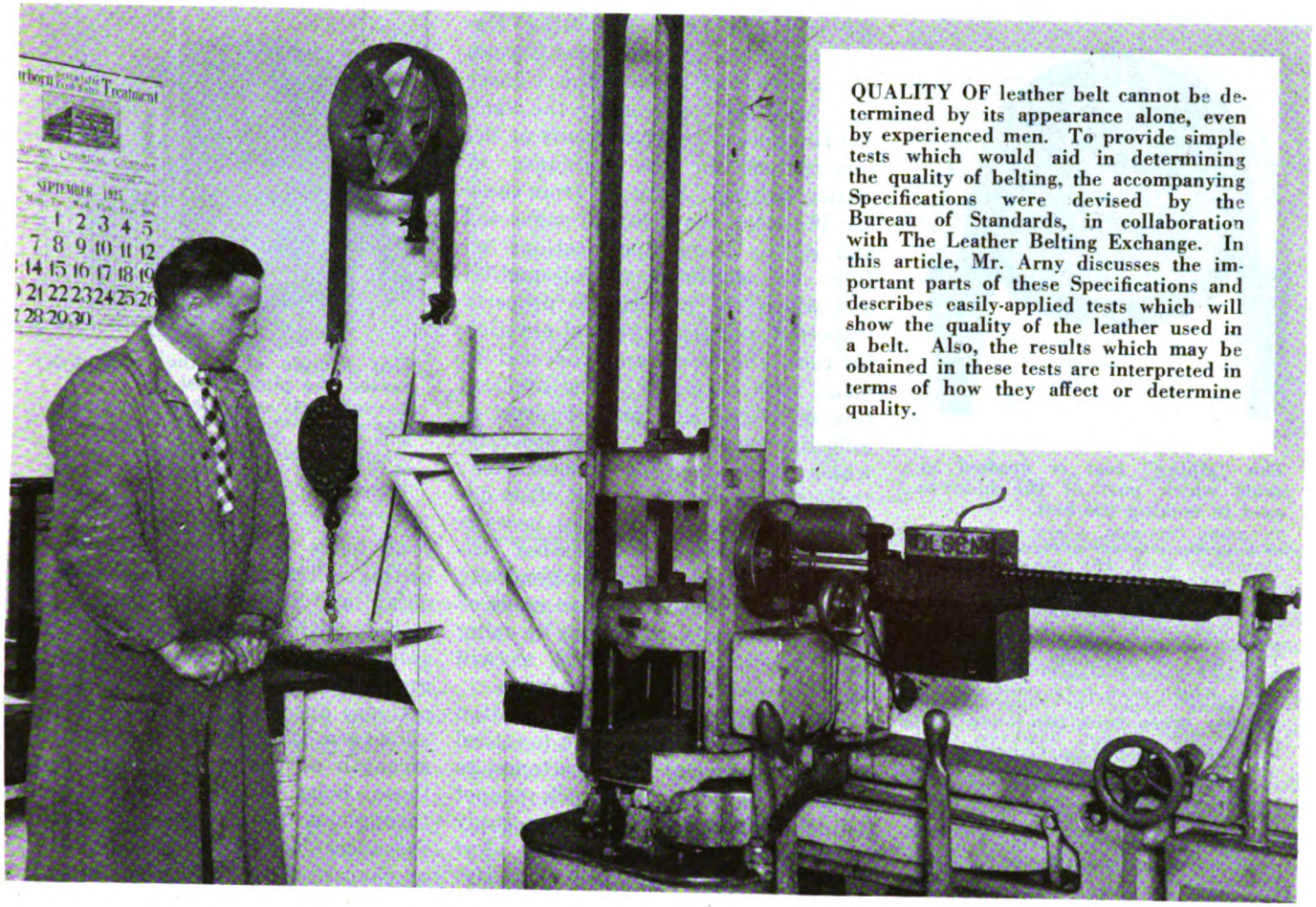


Fig. 4—These types of lighting equipment are used for special applications.

The unit shown in (1) is a metal reflector having a dust- and waterproof glass cover. Wire glass is used to minimize breakage. It is designed for use in shipping rooms, railway yards and like places. (2) is a unit for local lighting. A deep bowl reflector completely conceals the lamp, thus protecting against glare. It is suspended on a cord which can be adjusted to any desired height, or raised out of the way. (3) is a silvered glass reflector for use where the mounting height is high, as above traveling cranes, and where it is not necessary that any light should reach the ceiling. (4) is a prismatic-glass reflector. Ample light goes upward to illuminate the ceiling. This reflector is adjustable for lamps of different sizes. Marks on the stem indicate the position of the support for the various sizes of lamps. (5) is a prismatic-glass, vaporproof unit for use with lamps which are not so large as to produce objectionable glare. (6) is a metal reflector having a holder to take a vaporproof glass enclosing globe. It is intended for use in chemical plants, in paint and varnish rooms or in places where there is danger of igniting dust. (7) is an elliptical angle reflector for lighting wide spaces, or to supplement lighting from overhead units which are mounted high. It is suited for interiors with high ceilings, exterior lighting in yards, roadways, walks, etc. (8) is an angle reflector for lighting smaller areas similar to those mentioned in (7).

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QUALITY OF leather belt cannot be determined by its appearance alone, even by experienced men. To provide simple tests which would aid in determining the quality of belting, the accompanying Specifications were devised by the Bureau of Standards, in collaboration with The Leather Belting Exchange. In this article, Mr. Arny discusses the important parts of these Specifications and describes easily-applied tests which will show the quality of the leather used in a belt. Also, the results which may be obtained in these tests are interpreted in terms of how they affect or determine quality.

Making adhesion tests on a strip of belting leather.

This illustration shows a representative of a large industrial organization making acceptance tests in the laboratory of the Chicago Belting Company. Here a strip of belt is placed over a fixed pulley with a 56-lb. weight at one end and a special spring scale and lever at the other. The operator pulls down on the lever until the belt starts to slip, which raises the weight and is indicated by the hand on the dial of the scale turning backwards. The reading on the dial plus the weight of the scale minus 56 lb. gives the adhesion on the pulley. The belt is 1½-in. wide so that the 56 lb. represents a tension of 36 lb. per in. of width, which represents standard operating practice. The Olsen testing machine at the right is used for making tensile strength tests. Industrial plants which do not have testing machines similar to this will find commercial testing laboratories in practically all cities of any size.

Simple and Practical Tests for

Determining the Quality of Leather Belts

Whereby Operating Men Can Easily Ascertain Whether the Proper Quality of Leather Has Been Used for the Service Required

By LOUIS W. ARNY

Secretary, The Leather Belting Exchange, Philadelphia, Pa.

LEATHER belting, like many other materials used in industrial work, cannot be judged by appearances alone. The purchaser is buying ability to transmit power continuously and with a minimum of servicing. The appearance and feel of the belt, except to a man who is engaged in the manufacture of belting, and even he can be deceived sometimes, indicate but little about the reliability of the belt in operation. Because leather belting is a technical commodity which is sold commercially, the fact that it is technical is altogether too often overlooked. In many cases neither buyer nor seller has any knowledge of its technical nature. Too often the buyer thinks "a belt is a belt" and buys from the lowest bidder.

Ten years ago belting was almost purely a commercial product; today, it is highly technical. Much of this difference is due to the way belting manufacturers have used the work which has been done by the Research Laboratory under the direction of the Engineering Department at Cornell University, which has been maintained by The Leather Belting Exchange. Here studies have been made on the performance of belts in motion, the methods of operation, the characteristics of the materials of which they are made, their manufacture, and their adaptation to their purpose. Engineering, chemistry, photography and microscopy have contributed toward the solution of the problems of belt transmission, and those belting manufacturers who have participated in this work and have studied the effects of stresses and strains and of tensions and slippage, have been educated in the

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The "piping" test is applied to show which part of the hide is used in making the belt.

To make this test, a piece of single belt is bent over a form 2 in. in diameter, with the grain or hair side next to the form. If the belt wrinkles on the inside, as shown here, it can be assumed that the belt was made from leather taken from the lower part of the side. This part of the hide is used for making second- and third-grade belts, which give very good service in some types of applications. Leather taken from the lower part of the side is not, however, used by belting manufacturers for first-quality belts. Belting made from the lower part of the side not only has considerable stretch but a comparatively small amount of elasticity which makes it unsatisfactory for severe conditions. Under many ordinary operating conditions belts do not get severe service and so these factors do not make any particular difference.

manufacture of belting as a technical unit in transmission, and are making belting today to serve a technical purpose.

It has always been difficult for those who have only a casual knowledg of leather to detect inferior qualities of leather belting, or to recognize superior qualities. The leather belting market always has more than its share of inferior product; one reason for this is that, on casual inspection, the inferior and the superior belt look so much alike that relatively few can distinguish between them by appearance alone. Research work in leather belting has, however, shown a large difference between the values of good and poor belting.

Efforts to make possible a closer discrimination between qualities have been made through the establishment of Standard Specifications for leather belting, by collaboration between The Leather Belting Exchange and the United States Bureau of Standards at Washington. These Specifications are used by the various Bureaus and Departments of the Government in the purchase of leather belting. Extracts from these specifications are given on pages 482 and 483. These Specifications go fully into all the details of quality, and where the material is properly inspected and tested, discrimination between the good and the bad is made with certainty. The application of a complete test, however, is difficult, except for those concerns which have testing laboratories; those not so equipped must often depend upon the judgment of persons not well informed about leather. Industrial men, however, can generally determine whether belts are made of the poorer grades of leather by using only a part of these tests, as will be explained later in this article.

These Specifications are written from both a technical and a practical point of view and do not attempt to include requirements which cannot be determined directly from a study of the piece of leather belting. For example, former methods of specifying leather belting required that the belting should be made from "Packer No. 1 Steers" and that it should be cut not more than a certain distance from the backbone. Neither of these requisites can be determined from a study of the leather itself, and so were omitted in these Specifications.

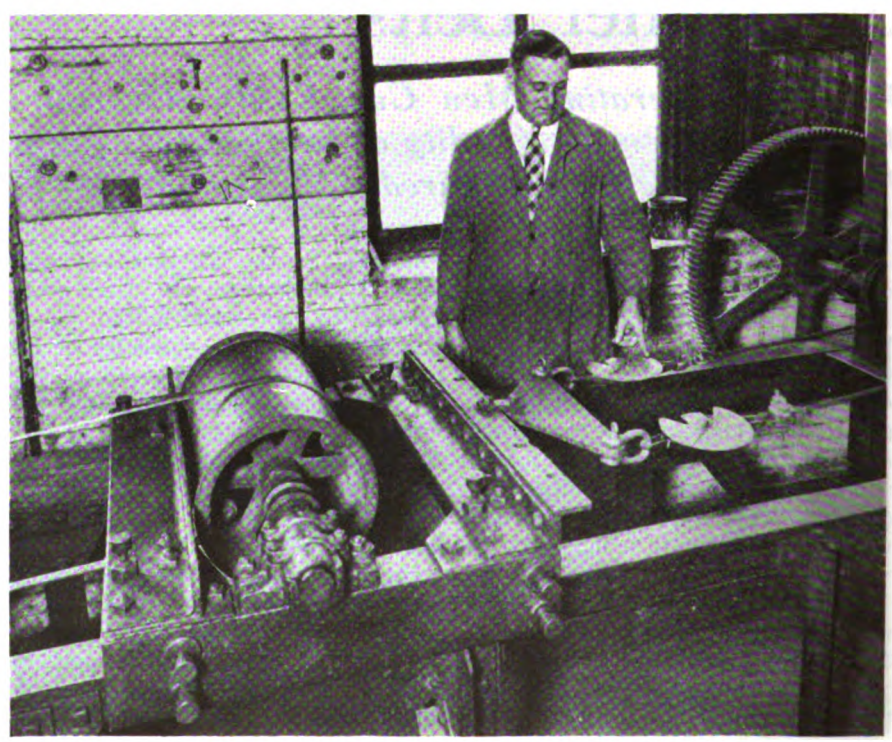
Also, many specifications prohibit grub holes in the leather used in belting. The practical difficulty of obtaining a sufficient amount of leather without grub holes was recognized and so a certain number of grub holes (Paragraph 2, in Specifications) are permitted. However, no allowance is made in the required strength of the belt on account of these holes. The idea in mind throughout the preparation of these Specifications was to give qualities or characteristics which would indicate good belts, and could be easily applied with a reasonable degree of speed and accuracy.

These Specifications require certain qualities in leather and provide numerous tests for determining these qualities. All of these tests are necessary to classify fully the quality of the belt. In many cases,



This sample of leather belt has passed the piping test.

As will be seen, this sample of single leather belt does not "pipe" when bent over a form 2 in. in diameter. Heavier belts are tested by bending over a form of larger diameter.



Here a belt is undergoing the running-in test.

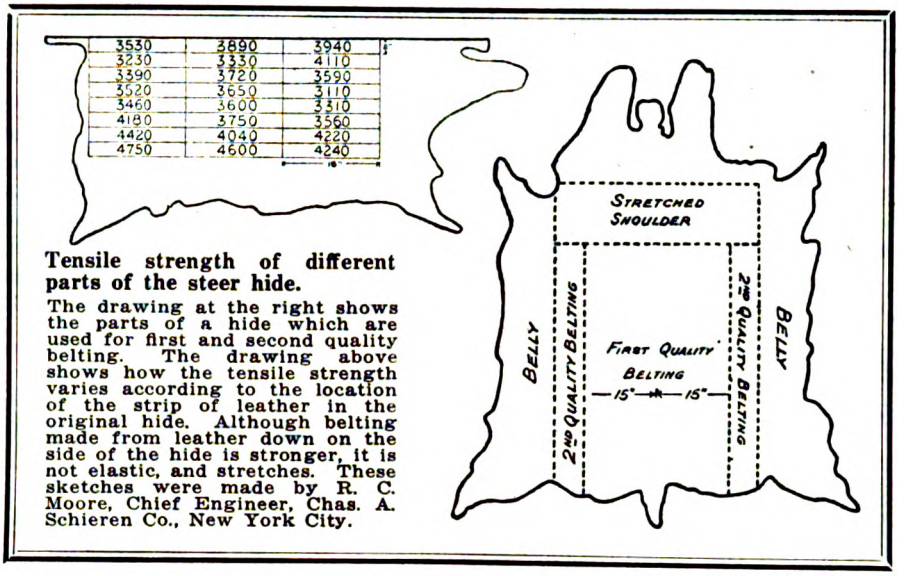
A piece of belt is placed under tension, the amount of which is indicated by the dials in the cables at the right, and driven to determine its straightness in running, and the temporary and permanent stretch from which the elasticity is computed. This illustration was also taken at the Chicago Belting Company's laboratory.

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The cracking tests also help to determine the quality of the belt.

In making the cracking test, a sample of belting is bent over a special form in much the same way as in making the piping test, but with the grain side out. If small cracks develop in the leather, the belt has not been properly curried. Currying consists in working into the belt the proper amount of animal oil or grease to replace the natural oils and greases removed in the tanning of the leather and provide a lubricant for the fibers in the leather.



Tensile strength of different parts of the steer hide.

The drawing at the right shows the parts of a hide which are used for first and second quality belting. The drawing above shows how the tensile strength varies according to the location of the strip of leather in the original hide. Although belting made from leather down on the side of the hide is stronger, it is not elastic, and stretches. These sketches were made by R. C. Moore, Chief Engineer, Chas. A. Schieren Co., New York City.

however, definite inferiority is indicated upon the application of a few simple tests, without going very far into the Specifications.

Belting leather, as everyone knows, is made from the hide of beef cattle, preferably the steer; this hide is a fibrous covering provided by nature for the protection of the animal. The structure and composition of leather and the importance of these factors in leather belts are not so well understood. Hide is composed of an inner membrane, which lies next to the flesh, and an outer layer of finer fiber, in which the hair is embedded. The inner side of the leather is called the flesh side and the outside the grain side.

Between this inner layer of membrane and the outer layer of fiber are millions of little fibers which vary in length on different parts of the animal, but all are attached either to the inner membrane, or to the outer fiber, and to each other, thus forming a mat or felt of fibers, which in motion work on each other and possess great strength. Accompanying illustrations show a highly-magnified cross-section of steer hide and of leather. In the process of tanning this fibrous material is changed into a strong and flexible substance which is not affected by the ordinary solvents of nature, such as air, water and so on, and is very resistant to the attacks of fungi and bacteria; hence leather is probably one of the most durable materials we have.

Over the backbone of the animal the fibers are shorter, denser, and of slightly less tensile strength and less stretch. These fibers change in their nature farther down the side of the animal from the backbone; about half-way down the fibers are longer, but not so dense, and stronger. Farther toward the belly of the animal the fibers are still longer, with a higher tensile strength, but with more stretch and less elasticity. It is desirable, therefore, that belts should be made of the upper half of the side of the animal. This part constitutes, roughly, according to the size of the animal, a strip equivalent to about 15 in. wide on each side of the backbone. In the examination of belting, the question therefore becomes important whether the belt is of first quality and is made of that portion above a line drawn 15 in. from the backbone, or whether it is made of that portion lying further down on the side and nearer the belly. The diagram of a hide shown above indicates the portions of the hide used in making first and second grade belts.

The part of the hide from which the belt was made can be determined with a reasonable degree of accuracy by the "piping" tests, which are provided in Paragraph 31 of the Specifications. This test consists of bending a piece of the leather around a form of a prescribed diameter with the grain or hair side on the inside of the bend. This test is based on the fact that the leather in the lower



Making the test for piping on a side of leather before it is used for belting.

This shows a side of leather after the part which is not used in making belts is trimmed off and the leather stretched. A piece about 30 in. wide in the center of this, extending about 15 in. on each side of the backbone, is used for making first-quality belts. The strips below that section are used for second- and third-quality belting, respectively. Courtesy the Chicago Belting Company.

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half of the hide with its longer and looser fibers is softer and spongier than the upper part, and that the grain surface of the leather is not so firmly attached to the inner fiber. When bent over this form, belt from the lower part of the hide will usually develop wrinkles or "pipes" in the grain on the inside of the bend, as shown in an accompanying illustration.

It is possible to produce pipes in almost any piece of leather by bending it often and close enough, and applying sufficient force. To make the test perfectly fair the Specifications provide that a single leather belt shall not show pipes, or piping, when bent over a form 2 in. in diameter; a double belt up to 17/64 in. thick when bent over a form 4 in. in diameter; and a double belt 19/64 in. thick or over when bent over a form 6 in. in diameter.

Practically all leather stock from the lower part of the side will show piping under this test even when it has been rolled hard to prevent it showing; hence, it is not desirable for severe belting service because it does not offer a firm pulley surface. Occasionally, also, pieces from the upper part of the hide will show pip-

Specifications for Testing Leather Belting to Determine Quality

I. Material Covered

(1) These specifications are for use as the basis of purchase for miscellaneous sizes, single and double ply, of first quality vegetable tanned (so-called oak tanned), leather belting for general use; also waterproof-dressed and waterproof leather belting.

II. Standard Specifications

A. Quality of the Leather

(2) All belting leather shall be made from green salted hides, and be free from brands, soft or spongy spots, and open grub holes, excepting that when made into belting, 30 per cent of the strips in any belt, or roll of belting, may contain a maximum of three open grub holes in each of such strips.

(3) The hides shall be tanned with oak bark, or a combination of vegetable tanning materials.

(4) *Stuffing*—Animal oils and greases shall be used for stuffing the leather, or a mixture of these and mineral oils in such proportion as will provide maximum strength and pliability.

(5) *Adulteration*—The use of Epsom salts, glucose, barium chloride, or other materials for weighting the leather, is prohibited. The presence of a greater amount of stuffing content than hereinafter specified shall be considered as adulteration.

(6) *Stretching*—All leather after stuffing shall be thoroughly stretched while still damp, and left under tension until dry. All belt pieces shall have the stretcher marks cut off.

(7) *Finish*—The grain or hair side shall be finished smooth, and the leather shall be thoroughly fleshed.

(8) *Cutting*—All strips shall be cut from the center portion of the hide, at such distance from the backbone as to include only firm stock, and to exclude second quality leather, and at such distance from the root of the tail as will exclude all shoulder stock, provided that the length of the strips shall be as hereinafter specified.

B. Construction of the Belting

(9) *Length*—No sectional strip shall be more than 54 in. in length, including the lap. The minimum length of any strip shall be 36 in. including the lap, excepting that in double belts one-eighth of the total number of pieces may be between 20 in. and 36 in., provided that these short pieces shall not occur consecutively. The minimum length shall not apply to the end pieces of rolls or cut lengths.

The Bureau of Standards of the Department of Commerce, in collaboration with The Leather Belting Exchange, an association of leather belt manufacturers, devised the following specifications which are used in testing leather belting purchased by the Departments of the Government.

(10) *Joining*—In single belting the strips shall be joined shoulder end to shoulder end, and butt end to butt end. In double belting the pieces shall be joined shoulder end to butt end.

(11) *Selection*—In all single belts 8 in. and over in width, backbone center strips shall be used. The backbone mark must appear running lengthwise approximately in the center of each strip. In all double belts from 8 in. up to 10 in. in width, backbone center strips shall be used in one ply and the backbone mark shall appear running lengthwise approximately in the center of each strip. The other ply shall be cut from the location prescribed for first quality stock. In all double belts 10 in. and over in width, both plies shall be made from backbone center strips, and the backbone mark shall appear running lengthwise approximately in the center of each strip. The same quality of leather shall be used in both plies of all double belting.

(12) *Length*—The length of laps shall be within the following limits:

Table I. Length of Laps in Inches

Thickness Ply—In Inches	Length of Laps: Belts, Under 6 In.	Belts, 6 In. and Over
Single—		
Under 10/64	2½ to 6	3 to 8
10/64 and over	3 to 8	3½ to 10
Double—		
Up to 17/64	2¼ to 3½	3 to 4
19/64 and over	3 to 4	3 to 5

(13) *Location*—The minimum distance between any two laps in the separate plies of double belting shall be 8 in.

(14) *Point of Lap*—The point of all laps shall be at right angles to the edge of the belt.

(15) *Direction*—All laps shall run in the same direction.

(16) The laps of both single and double belts, and the plies of double belts, shall be thoroughly cemented together. When pulled apart the cemented surface shall not appear glazed or shiny.

Width

(17) *Standard Widths*—The standard widths of belt shall be from ½ in. to 72 in., increasing by ¼ in. up to 3 in.; ½ in. to 6 in.; 1 in. up to 10 in., and 2 in. above 10 in.

(18) The maximum variation from the nominal width shall be in accordance with the following:

Table II. Tolerance from Nominal Width

Width of Belting	Tolerance
Under 2 in.	Not less than nominal
2 to 24 in. inclusive	One per cent
Above 24 in.	½ of 1 per cent

Thickness

(19) The thickness for the different grades of belting shall be in accordance with the following:

Table III. Thickness of Belts

Grade	Average Thickness in Inches: Single Ply	Double Ply
Light	8/64 up to 10/64	15/64 to 17/64
Medium	10/64 up to 12/64	19/64 to 21/64
Heavy	12/64 up to 14/64	23/64 to 25/64

The average thickness shall be determined by measuring the thickness of 15 to 20 plies of the belt when rolled, and dividing this value by the number of plies measured.

(20) *Uniformity*—No point in either single or double belt shall be more than 2/64 in. thicker, nor more than 2/64 in. thinner than the average thickness.

(21) *Leveling and filling*—The excessive use of shims and filler strips and excessive splitting or leveling is prohibited.

(*Continued on the opposite page*)

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ing under this test. However, regardless of the part of the hide from which the piece is taken, the presence of piping indicates a looser fiber than is required for the best leather belting, and in most cases indicates that the leather was taken from the lower part of the side.

It is not possible to determine much about the quality of the leather by its feel, because the makers of inferior commercial grades of belting have learned the trick of rolling and "jacking" (rubbing in one direction with a glass head) their leather, and filling it with materials, such as Epsom salts, glucose, barium chloride, and others, to solidify it, that make the "feel" very deceptive. The piping test, if properly applied, will show the real quality of belting.

Still another test is applied by bending the leather over a similar form, with the grain side outside, to detect cracking of the grain, as discussed in Paragraph 30 of the accompanying Specifications. If this test shows that the leather cracks, that is, if it develops a series of minute cracks running across the width of the belt, the material either has not been properly tanned, or has not been properly curried, and is not

Specifications for Testing Leather Belting to Determine Quality

(Continued from the preceding page)

(22) All belting shall be stamped on the grain side with the maker's name and brand; and a stamp indicating the direction in which the belt is to run. Each stamp shall be repeated every 10 ft. throughout the entire length of the roll of belting.

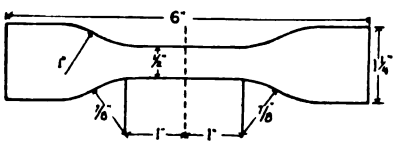
(23) *Waterproof-dressed belting*—This type of belting shall conform to all the requirements of this specification. In addition it shall be treated with a waterproof dressing.

(24) *Waterproof belting*—This type of belting shall conform to all the requirements of this specification. In addition, it shall be treated with a waterproof dressing. The laps and plies shall be cemented with a waterproof cement.

III. Technical Tests

A. Physical Tests

(25) *Leather*—All leather shall have a minimum tensile strength of 3,000 lb. per sq. in. of cross section, an average tensile strength for single belts of 3,750 lb. per sq. in., and for double belts, of 3,500 lb. per sq. in. The average shall be determined with five test specimens selected at random from different parts of the sample being examined.



Test specimens of the size and shape as shown above shall be cut with a metal die. The edges of the test specimen shall be cut perpendicularly. The minimum thickness inside the gage marks shall be used in determining the area of the cross section of the test specimen.

(26) *Laps and plies*—The laps of both single and double belting shall not open when subjected to a tensile stress of 2,500 lb. per sq. in. The opening of the laps shall be determined by testing two specimens cut across the point of the lap lengthwise of the sample. For double belting the test shall be made on the single ply.

(27) The average elongation at a tensile stress of 2,500 lb. per sq. in. shall not exceed 15 per cent. The average shall be determined with the same five test specimens used for determining the tensile strength.

To determine the amount of elongation, parallel gage marks 2 in. apart shall be placed upon the restricted portion of the test specimens. The distance between the gage marks shall be measured with a pair of spring dividers, at a tensile stress of 2,500 lb. per sq. in. The amount of stretch shall then be determined by measuring the opening of the dividers on a scale.

This test will be made on each lot of 2,000 ft., or fraction thereof.

(28) The following stretch test shall be made on the finished belting up to, and including, 6 in. in width. Any section of a roll or belt shall be selected (which shall not be cut out) on which gage marks shall be placed 10 ft. apart. Suitable clamps shall be attached on the marks so that the distance between the clamps shall be 10 ft. The section shall then be suspended in a vertical position from one of the clamps. Sufficient weight, including the weight of the clamp, shall be attached to the lower clamp to produce a tensile stress of 750 lb. per sq. in. of the average cross section of the section being tested. The section after being subjected to this tension for 15 min. shall show a length between gage marks not to exceed 10 ft. 7.2 in. or 6 per cent stretch.

(29) *Measure of Elasticity*—The clamps shall then be removed, and the section allowed to lie loosely on the floor for 17 hr., after which time the length between the gage marks shall not exceed 10 ft. 1.6 in. or 1⅛ per cent of stretch.

(30) The leather shall not crack on the grain side, and the laps shall not open at the points, when the belting is bent through angles of 180 deg. grain side out, over forms as specified, Table IV, for the different grades and thicknesses.

Table IV. Forms for Cracking Test

Belt	Thickness, In.	Diameter Form, In.
	Under 10/64 (Average)	1
Single	10/64 and over	1¼
	Up to 17/64	3
Double	19/64 and over	4

(31) The leather shall not show wrinkles on the grain side (commonly called "piping," and indicating looseness of fiber found in "side-stock," or second quality belting), when bent through angle of 180 deg. with grain side in, over forms as specified below for the different grades and thicknesses.

Table V. Forms for Piping Test

Belt	Thickness, In.	Diameter Form, In.
Single	All	2
Double	Up to 17/64	4
	19/64 and over	6

Water Absorption Test

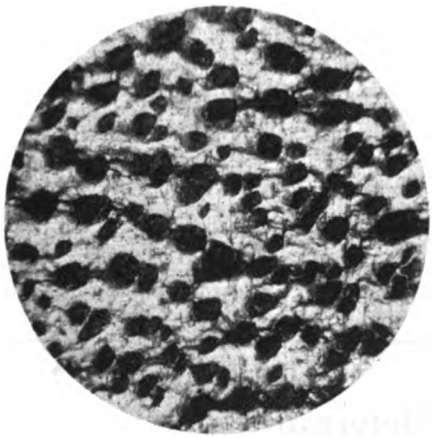
(32) A sample of waterproof-dressed, or waterproof belting, 12 in. long, shall be weighed, and then immersed in water, at room temperature for 5 hr. When removed from the water, the sample shall be wiped and again weighed. The percentage of water absorbed shall not exceed 8 per cent. This test shall be made on every lot of 2,000 ft., or fraction thereof.

Testing of Waterproof Cement

(33) The sample of waterproof belting tested for water absorption shall be again immersed in water, until the total period of immersion is 24 hr. The sample, after removal, shall be allowed to dry under room conditions for 24 hr. The laps and plies shall not open when the sample is bent around the proper form, as specified in Paragraph 30.

NOTE: The remaining paragraphs of the Specifications cover the chemical tests of leather and the results which are required. The facilities of a chemical laboratory are needed to make these tests but they are not too difficult to be carried out by any industrial chemist. Industrial men who have the necessary facilities and desire further information on these chemical tests may obtain a complete set of Specifications by addressing Louis W. Arny, Secretary, The Leather Belting Exchange, 417 Forrest Bldg., Philadelphia, Pa.

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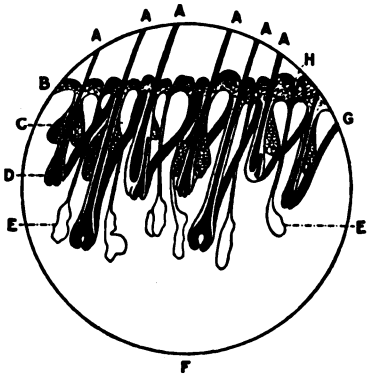


The natural grain of the leather and the fibrous cushions which grip the pulley.

This piece of belt surface has not been worked so heavily as has the leather in the accompanying illustration at the right. It is possible by working or jacking, which is a process of polishing by rubbing in one direction with a glass-headed tool, to put a high finish, even on a low grade of leather, so that appearance is very deceptive in judging the quality of leather. However, a belt which has been worked or jacked heavily, does not transmit as much power as does leather which is left more nearly in the natural condition.

suitable for serviceable belts. Currying is the process of working animal oils or greases into the leather to replace the natural oils or greases which are removed during the tanning process. This makes the leather pliable and lubricates the fibers as they move on each other when the belt is bent and straightened as it passes over the pulleys.

The next important test is the tensile strength test, although it is important only in connection with other tests, since the poorest part of the hide shows the greatest tensile strength. Hides vary so much in substance and strength in their different parts, that it is not possible to test but one piece of belting and to consider the result as the tensile strength of the entire belt. The specifications (Paragraph 25) meet this condition by providing that the test shall be made on five test specimens, selected at random from different parts of the sample being examined, and that these shall average 3,750 lb. per sq. in. of cross-section, and that the minimum shall be not less than 3,000 lb. This is an assurance against bad tanning, and will expose any leather that is burnt by any of the tanning processes. Of course, 3,750 lb. per sq. in. is a relatively low tensile strength for this material for most of it will go to between 5,000 and 6,000 lb., but it is quite sufficient to determine that the leather is not inferior. Furthermore, it is about ten times as much stress as the belt ever will be required to withstand in actual service; thus, it seems to be quite sufficient.



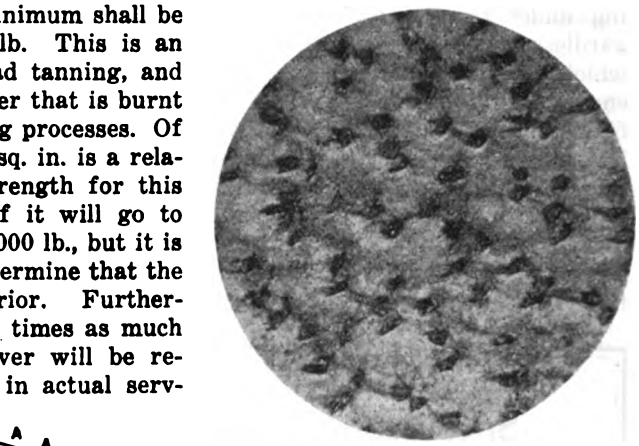
Cross section of the hide of a steer before it is made into leather.

Although the skin is made up of many parts, it is readily divided into two distinct layers, the epidermis and the corium, which are both distinct in their functions and different in their structure. The epidermis *B* forms a thin outer layer of the skin. The hair *A* extends deep into the corium *F* and ends in hair bulbs *D*. The muscles *G* contract and raise the hair perpendicularly under the influence of fear or cold. *H* is the duct to the sweat gland *E*. *C* are glands which lubricate the hair. The corium *F* is made up of cells and fibrous material which give the skin, and also the leather, strength. This illustration and the information on the structure of cowhide are abstracted from "The Manufacture of Leather" by Hugh Garner Bennett, which is published by Constable & Co., Ltd., London, Eng., and distributed in the United States by D. Van Nostrand Co., New York City.

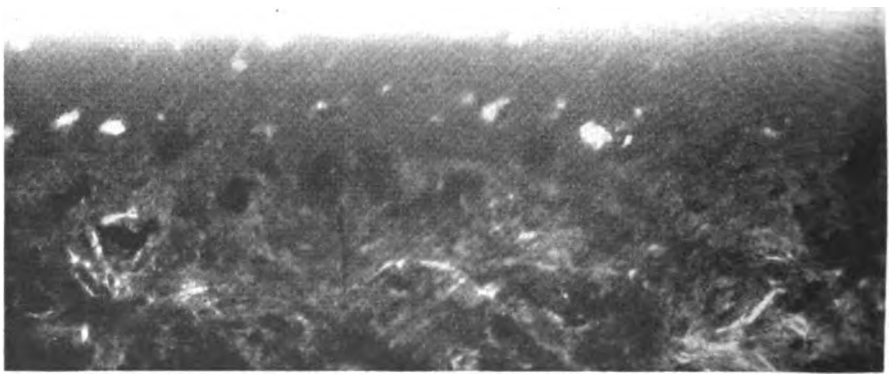
The stretch or elongation test (Paragraphs 27, 28 and 29) should be applied with the tensile strength test, by placing parallel gage marks 2 in. apart on the test specimen, stopping the machine when it has reached 2,500 lb. per sq. in., and measuring the elongation, which must not exceed 15 per cent. This is quite liberal to the belt for most of the better belts will not elongate to this extent. A high tensile strength, when accompanied by an excessive stretch and small elasticity, also indicates that the leather stock was taken from the lower part of the side, while a lower tensile strength accompanied by not over 15 per cent stretch, and better elasticity, indicates center stock. These tests will determine the part of the hide from which the belt has been made.

The chemical tests provided in these Specifications are very interesting, and where very accurate results are desired they are necessary. However, the tests already enumerated will demonstrate whether a leather belt is cut from the upper or lower half of the side, and whether it may be depended upon for good service in the plant. If it is found to be markedly defective under the chemical tests, deficiencies most

(*Please turn to page 506*)



This illustration, which is magnified several times, shows how the grain of the leather is smoothed down after a violent rolling or jacking.



A highly magnified cross-section of leather belt.

The top of this illustration shows the grain or hair side of the leather. The openings, from which the hair has been removed, provide a rough, vacuum-cup surface which helps the belt to grip the pulley. When the belt is "jacked" to give it a high finish, this surface is smoothed down and as a result does not transmit as much power as when less highly finished.

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Some Pointers on

How to Find the Lead Throw of Armature Coils

For Any Brush Position When There Is an Extra Commutator Bar and Coil, by Expressing Top and Bottom Lead Throws in Number of Bars

By A. C. ROE

Renewal Parts Engineering Dept., Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.

and

D. H. BRAYMER

Consulting Editor, Industrial Engineer.

IN THIS ARTICLE a method is described for connecting coils to the commutator bars by expressing the top and bottom lead throws in number of bars. For any brush position, first locate the nearest polepiece and the brush. As shown in Fig. 2, lay this angle off on paper. Then with the polepiece centerline as a base, lay off the coil pitch angle, B, so that angles A_1 and A_2 are equal. Next, subtract the angle A_1 from the angle between the center line of the pole and the center line of the brush and divide the remaining angle by the bar angle. This will give one lead throw. This is the basis of a very simple and accurate method that can be used in almost all cases, when it is thoroughly understood. The details given in this article explain how the method is applied.

IN THE article that appeared in the September issue some practical pointers were given on winding direct-current armatures. In that article methods were outlined for taking data and marking the armatures to prevent errors in rewinding and in connecting leads to the commutator. At the end of the article reference was made to those cases where a half-idle bar is used and to the method of bringing out coil leads and connecting them to the commutator.

Another method of dealing with windings using an extra bar and coil is taken up in what follows. This method as applied to a particular winding is shown in Fig. 1, in which a 24-bar and a 24-slot, 4-pole winding is illustrated to bring out the principle involved. The extra coil is used to jump two bars together so that they form one large bar. This method uses all the coils and bars and each bar has the regular number of leads attached to it; that is, one top and one bottom lead. In Fig. 1 the coil marked *Jumper Coil A*, has the top lead connected to bar *24* from the top of slot *24*, this being the standard top lead throw. The bottom lead of this coil is brought around to the adjacent bar to the right of its top lead like in a lap winding or to bar *1*. A study of Fig. 1 will show that the bottom lead of this same coil from slot *6* bends in towards the center of the coil and connects to bar *1*. Thus bars *24* and *1* are bridged together.

Then starting with coil *B*, we can lay off the standard lead pitch, which in this case is 12 or 1-and-13. The top lead of coil *B* connects to bar *1* and the bottom lead to bar *13*. The top lead of coil *C* in the top of slot *13* also connects to bar *13*. The bottom lead of coil *C* should connect to a bar that is 1-and-13 from the lead pitch. By counting bars *24* and *1* as one bar, this brings the bottom lead to bar *2* and completes the series, forming a progressive winding. To check this winding, start at bar *23*, top lead, and go through slot *23* to bar *12*, to top slot *12*, to bar *24* through coil *A* to bar *1*, then to coil *B*, to bar *13*, to coil *C* and bar *2*, etc. This method can be used when there is one bar and a single coil too many.

When starting a winding with this type of coil, put the first coil in and lay off its top lead pitch. Then bring the bottom lead around to the adjacent bar and mark these two bars so that they can be found again. The next coil put in has the bottom lead laid off according to the standard throw, and the rest of the bottom leads will be standard until the bar that has the bottom lead of coil *A* is reached. Then from there on the bottom lead throws will have to be increased one bar, as shown in Fig. 1, or the number of long, bottom lead throws will be one less than the lead pitch expressed in bars. In this case it is, 12—1 or 11 slots.

Next, the rules for locating bar *D*, in Fig. 5, page 284 of the June issue, will be given. This locates the bottom lead throw when the bottom slot, instead of the center line of the coil, is used to line out from. First we consider the case where the center line of slot *A* falls on the mica. This is shown in Figs. 5 *II* and 5 *IV*, June issue, page 284. The number of bar *D* (with bar *C* taken as No. 1) will be $[(CP+R)-(B\times T\div S)]\div 2$; where CP equals the lead pitch in bars, R equals one-half the number of coils per cell, B equals the total number of bars, T equals the coil pitch in slots and S equals the total number of slots. When the line falls on a bar add ½ to the result obtained from this formula.

For example, assume a winding with 35 slots, 139 bars, coil pitch 1-and-10, or 9, lead pitch 1-and-71, or 70. Then R equals $4\div 2$, or 2, CP equals 70, B equals 139, T equals 9, and S equals 35. From the formula, then, bar D equals $[(70+2)-(139\times 9\div 35)]\div 2$, or $(72-35.74)\div 2=18.13$ or bar No. 18. When the answer in either case results in a fraction, use the nearest whole number.

Take the case of Fig. 5 *V* (June issue, page 284) for 25 slots, 125 bars, coil pitch 1-and-7, or 6, lead pitch 1-and-64 or 63. Then R equals $5\div 2$, or 2½ and D equals $0.5+[(63+2.5)-(125\times 6\div 25)]\div 2$, equals $0.5+(35.5-30)\div 2$, equals $0.5+17.75$, or 18.25 or D should be taken equal to 18.

A more accurate method of locating the lead throw will be described next. By this method, the leads can also be located in proper relation to any brush position. Fig. 2 shows the principle. This method uses the center line of the coil as the base on which the top and bottom lead throws are laid off. In Fig. 2 the section of the coil marked *A* represents the top leads, *B* the top half of the coil, *C* the bottom half of the coil, and *D* the bottom leads. Note that the center coil is used for cases

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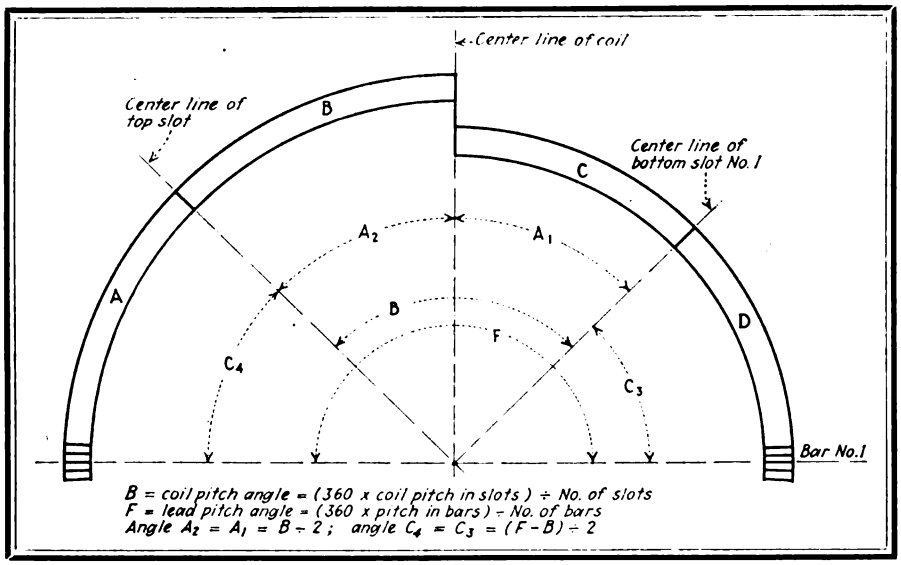


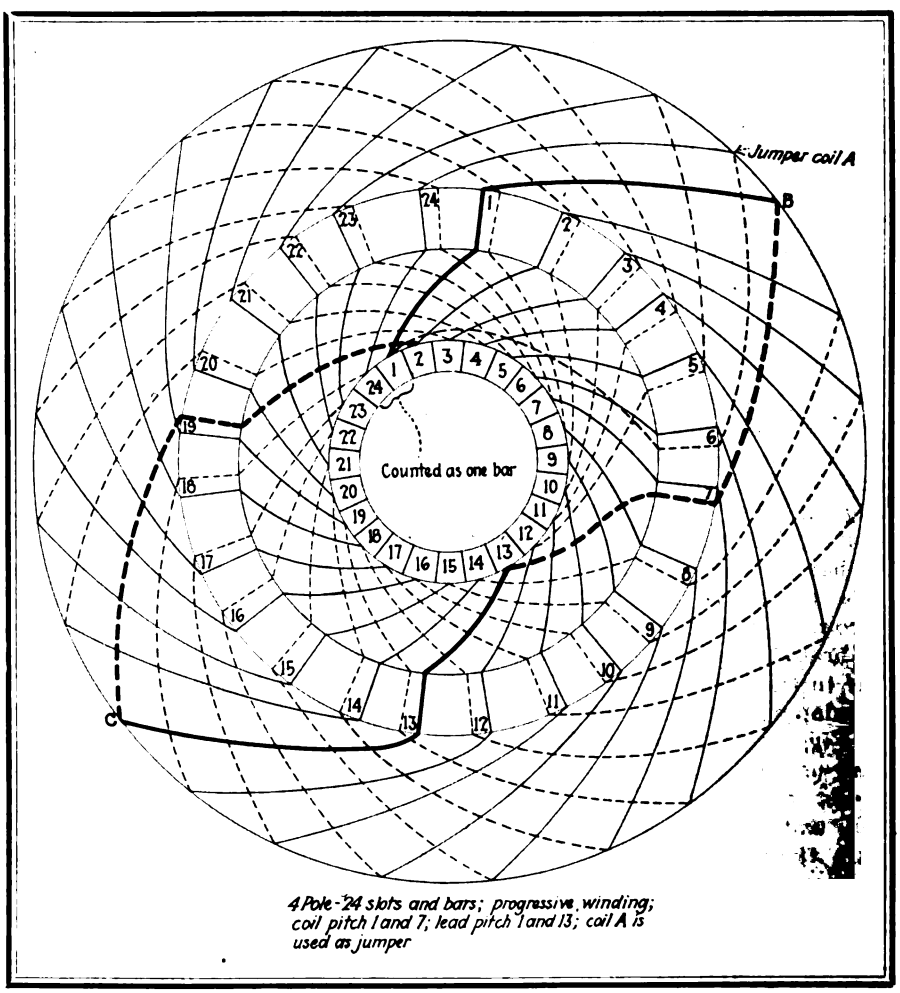
Fig. 2—In this diagram a method is shown for locating the lead throw of a coil in the proper relation to any brush position.

having an odd number of coils per cell. When an even number of coils per cell occurs, the single coil in the right-hand side of the slot should be used for a left-hand coil. For right-hand coils use the single coil to the left of the slot. In Fig. 2 the angle *F* equals the lead pitch in mechanical degrees, and is equal to (360× lead pitch in bars) divided by the total number of bars. Angle *B* is the coil pitch angle and is equal to (360×coil pitch in slots) divided by the total number of slots. Angle C_3 equals the bottom lead throw angle and angle C_4 equals the top lead throw angle. In most cases the top and bottom lead throw angles are equal. Angles A_1 and A_2 are one-half the coil pitch angle *B*. Then to find the lead throw we must know the number of slots, number of bars, coil pitch and lead pitch.

For example, assume a six-pole machine, with 100 slots, 200 bars, progressive wave winding, coil pitch 1-and-16, or 15 slots, lead pitch 1-and-68 or 67 bars. Then angle *B* equals (360×15)÷100=54 deg., and angle *F* equals (360×67)÷200= 120.6 deg. and *F*—*B* equals 120.6—54 equals 66.6 deg. Then angles C_3 and C_4 equal 66.6÷2 or 33.3 deg. To find the number of bars in each angle, first find the angle between each bar, which is equal to 360 divided by the total number of bars, or in this case 360÷200=1.8 deg. Then the number of bars in angle C_3 equals 33.3÷ 1.8=18½ bars. This would indicate that the center line of the bottom slot *1* is on the center line of the mica between bars *19* and *20* for 1+ 18½=19½ or half way between 19 and 20.

The reason for the above is explained by Fig. 3. In this case the base line is also the center line of bar *1*: then with an angle of 1.8 deg. between bars, the beginning of bar *1* is 0.9 deg. below the bar center line as shown. Then if angle C_3 is equivalent to 18½ bars, we count these from the center of bar *1* to the center of bar *19*, as shown by the figures on the bars reading from left to right, or 18 full bar angles. The half-bar angle will bring the count to the mica between bars *19* and *20* as shown. Thus we know that the center line of slot *1* falls on the mica between bars *19* and *20*. This would be sufficient information, but we can check the other angles to determine whether the top or bottom lead throws are equal. If the top throw is long, the extra throw in bars, if more than one bar, and an even number, should be divided in half and the one half added to the bottom lead throw. If the extra throw in bars is an odd number, add one bar more than half to the bottom lead throw. That is, for three bars longer top throw add two bars to bottom lead throw. By checking the example, angle *B* equals 54 deg. or 54÷1.8=30 bars. Counting from the end of the C_3 angle, 30 plus 19 brings the center line of the top slot, *16*, on the mica between bars *49* and *50*, as shown in Fig. 3. This

Fig. 1—This diagram for a four-pole progressive winding with 24 slots and bars, shows how coil A is used as a jumper.



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is due to the fact that we count from mica to mica, from the end of angle C_2. Next, angle C_1 equals C_2, 33.3 deg., or 18½ bars. Then 49 plus 18½ equals 67½ or the center line of bar *68*. The 18 full bars would bring the count to the mica between bars *67* and *68*, but the half bar angle throw (the angle to the center line of bar *68*) shows that the top and bottom lead throws are equal.

By this method the top and bottom lead throws can be found and expressed in bars. For any brush position, first locate the nearest polepiece and the brush. Lay this angle off on paper, as shown in Fig. 2. Then with the polepiece center line as a base, lay off the coil pitch, angle *B*, so that angles A_1 and A_2 are equal. Next, subtract angle A_1 from the angle between the center line of the pole and the center line of the brush and divide the remaining angle by the bar angle. This will give the one lead throw, or angle A_1 plus C_3. Then C_4 equals F—C_2 plus B_1. A little practice with this method will soon convince anyone that it is simple and accurate and applicable to all cases.

The following will describe a method of taking rewinding data from an armature that has been so badly roasted that the winding is full of shorts. In this case a test lamp will light regardless of whether the circuit is opened or not, as was explained in another article, by cutting off the two top leads on either side of the data coil lead. This method can also be taught to unskilled help, or beginners when they are employed to strip armatures. This method will enable this type of help to take and record the data and an experienced winder can check it in five minutes and catch any mistakes before all traces of the original data are lost.

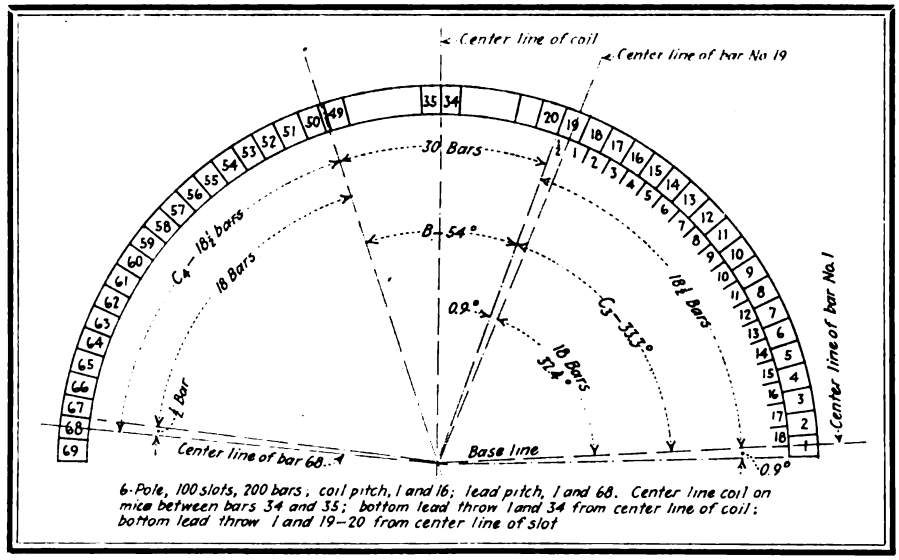
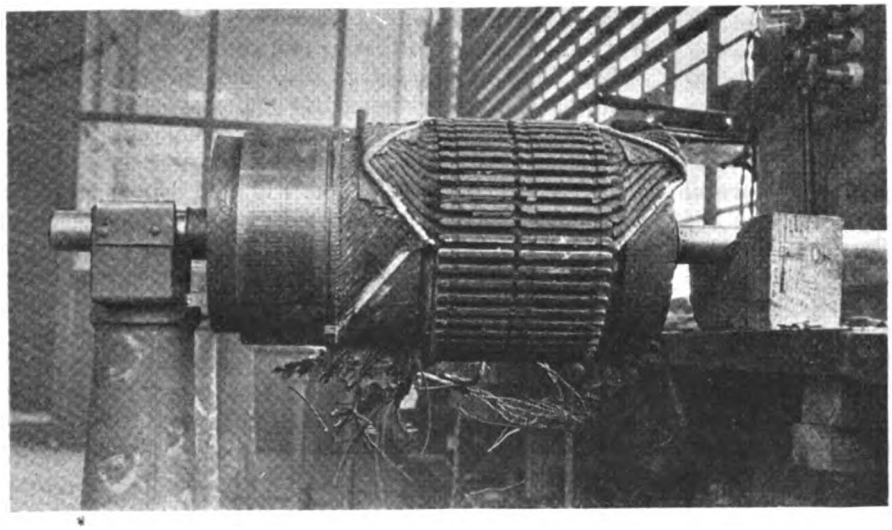


Fig. 3—This is a quick and convenient method for finding the top and bottom lead throws and expressing them in number of commutator bars.

This is purely a mechanical method. The core and end bands are removed; likewise any string or tape bands at the back of the commutator are also removed and all wedges are knocked out. Then select any one coil, and mark with two cross marks, the teeth on either side of the slot that contains the top half of the coil selected. Next, trace out the top leads to the commutator and mark the bars according to the instructions given for Fig. 5, June issue, page 284. Then if left-hand coils are used, cut off all the top leads back of the commutator with a chisel, or if they are strap copper, unsolder them and lift all top leads for a distance a little more than half-way around, starting with the leads to the right of the data coil leads and proceeding in a clockwise direction. For right-hand coils, take the leads to the left and proceed in a counter-clockwise direction. Lift all these top leads and remove any tape bands on the front ends or between top and bottom leads. When cutting off the top leads be careful that the bottom leads are not cut off also, as they are needed to check the lead pitch. Next, count off from the top coil slot a number of slots equal to one-half the total number of slots for four poles, one-third for six poles, one-fourth for eight poles, etc., and in a direction that is towards the bottom coil half; that is, clockwise for left-hand coils and counter-clockwise for right-hand coils. Then lift this top coil half just found, and lift all top coils back towards the marked coil. When the throw coils have been lifted, start pulling the complete coil out. Proceed in this manner until the data coil is reached, which should not be disturbed. Then if the coils have been pulled out and the bottom leads cut off each coil, the complete data coil will be exposed to view as shown in Fig. 4.

Fig. 4—Here the data coil is shown marked with chalk, from which the winding information can be secured as explained in this article.



It is then quite an easy matter to count the lead pitch and coil pitch, line out from the center of the coil or bottom slot with a piece of string or straight edge, and count off the bottom lead throw. The bottom slot can also be marked, as well as the bars to which the leads connect. The winding should be checked for any special features, such as dead coils, half-idle bars and so on. Also check the lead pitch for progressive winding. Then the armature can be pulled down and cleaned.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, October, 1925

Keep Tomorrow in Mind When You Plan for Today

OPERATING men generally have but small, detailed conception of what their plant will be like a few years hence. They do know, however, or at least have confidence, that the plant will be larger. This means more machines to each group, and perhaps more floor space, all of which are indicative of growth and increased demands for power service.

Although it is not always possible definitely to know future plans, it is generally not difficult to make some allowance for growth. One plant, for example, when laying out its group drives, designs an installation complete on the basis of a capacity of 25 per cent or more above all machines that are to go in at the time the shaft is erected. It is much cheaper to provide this extra capacity at the time an installation is first made, rather than later on, because in many cases the price of the hangers is the same, the cost of installation would be practically no different, and the only additional cost would be due to the increased size of lineshaft and bearings installed.

If such a plan were followed more generally, there would be less complaint of overloaded drives and the maintenance problems which they present.

Could You Afford to Have a Fire in Your Plant?

INDUSTRIAL plant executives may well devote part, or even all, of Fire Prevention Week, October 4-10, to careful consideration of one of industry's ever-present and potentially most serious dangers—fire. Failure of, and mishaps to, equipment are costly enough in loss of production, disruption of schedules and damage to property, but there is almost no limit to the damage that fire may do. Frequently it does not stop short of the complete destruction of the plant and its contents.

Despite the efforts that have been made, through educational programs and otherwise, to reduce the number and extent of fires, the total fire loss in this country last year amounted to $549,910,659, the greatest in our history. Roughly, it amounted to a little more than a million and a half dollars a day, or over a thousand dollars a minute. In the fires that caused these huge losses, nearly 15,000 persons lost their lives and more than that number of persons were injured more or less seriously.

It is estimated that 87 per cent of all fires are preventable and are caused by carelessness or ignorance, or both. If those whose carelessness or ignorance are responsible for fires could be made to bear the resultant losses, it is safe to say that there would be a decided reduction in the number of fires. As it is, every one of us helps to pay the annual fire loss. The fire insurance companies reimburse those whose property is damaged or destroyed, but the money thus paid out is all collected in the insurance premiums. Manufacturers then add these premiums to the cost of their products. Thus, the food we eat, the books we read, and the equipment we operate all have in their cost a part of our national fire loss. That is how the price of ignorance and carelessness is paid by innocent and guilty alike.

Careful inspection of your plant equipment and processes for the purpose of eliminating every possible fire hazard, and adequate fire-fighting equipment operated by trained men, will do much to enable you to keep that useful servant—fire—in its proper place. The chances are that failure to take every reasonable precaution against fire will some day exact a heart-breaking toll.

Are We Sometimes Good Liars and Actors?

IN A recent lecture in which the speaker dealt with some of the things that go on behind the screen of man's visible actions, he pointed out that most of us can be accused of being liars and actors, based upon the things we do. For instance, he pointed out that when we select an automobile there is a tendency to buy the large and flashy car; when we buy clothes for our family and ourselves we tend toward the purchase of things that make us look prosperous instead of comfortable; and when we display these outward evidences of prosperity and success it is in many cases under circumstances that will make us look good in Dunn's and Bradstreet's or to some individual or group with whom we desire a good standing socially or in a business way. And after all, there is more truth than poetry in these comments.

This kind of psychology also finds its way into our business and professional life and if you look around you among the engineers and plant men you know who are clothed with authority and make decisions on the purchase of equipment, you will find plenty of cases where the use of good reliable equipment is passed up for some automatic thing-a-bob which is claimed to do this or that—and sometimes does. When being shown through such a plant, how many times can you remember that your attention has been called to these fancy frills of engineering, as compared to the cases where your attention has been called to some worn and battered piece of equipment that has stood the test of abuse and years of use and paid a wonderful return on the investment?

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Roll these thoughts over in your own mind and judge for yourself whether you are a good liar and a good actor when it comes to the exercise of your engineering judgment and ability, and can prove your answer to those who expect you to tell the truth and live and act by it, by a thorough investigation of your operating results.

Portable Power-Driven Tools for Maintenance Work

ONLY too often is the value of portable, power-driven tools overlooked in maintenance work. Because only a few holes have to be drilled, a small piece sawed out of a floor, or a little cut taken off a casting, hand methods using a star drill, an "old man" and a ratchet drill, a file, or a handsaw are employed.

How often is it that we find a workman using a star drill and hammer to cut half a dozen holes in a concrete wall for mounting some piece of equipment? Although the star drill and hammer do not cost much money, the workman's time is expensive. If there is much work of this character an electric hammer for driving the star drill will soon pay for itself.

Then too, the electric drill with a grinder attachment should find a place in any plant maintenance department. There is no question as to the saving that it can accomplish over hand methods of drilling and filing. Quite recently several motor-driven saws have been developed by different manufacturers. These saws will cut flooring or walls and do the general sawing required in plant maintenance in less than one-fifth of the time required by hand.

It is a mistake to think of portable, power-driven tools as being made only for production work. They have a definite place in your maintenance department. If you are trying to cut maintenance costs why not let these tools replace some of your extra helpers?

Machines That Never Run Right

IN AN item in the department, "Mechanical Maintenance of Power Drives," on page 501 of this issue, Donald A. Hampson tells an interesting story of a machine that "never ran right." In spite of the fact that a companion machine just like it operated satisfactorily, the men in the shop treated this machine as though it were bewitched, or had a hoodoo.

Finally, the machine came under the attention of an engineer who remembered that the last witch had been hung many years ago. This man knew that the machine did not operate properly because something was wrong. When he could not find out the cause of the trouble he promptly called in outside assistance and had an extensive investigation made, instead of the superficial examination which had always been made previously. His experience showed him that the trouble could be due only to misalignment. It was a hard job to find how far the shafts were out of parallel and so the others who had worked on the machine had dismissed this factor with the assumption that "they ought to be parallel." A careful check by a man who knew how and took the time to make it, proved that the shafts were out of parallel about 1 in. in 50 in. Correcting this removed the hoodoo, and the machine gave no further trouble.

The good engineer will leave no stone unturned in making a thorough investigation of an operating trouble. No assumption can be made that "it ought to be right" without proof to back it up. Acknowledgment that a machine "will not run right" is practically a confession of ignorance, or incompetence, or inability to discover the real cause of the trouble. A piece of machinery does not have any inherent wickedness; it operates improperly because something is wrong and the only thing to do is to find the trouble and correct it.

The Hiring and Firing of Men

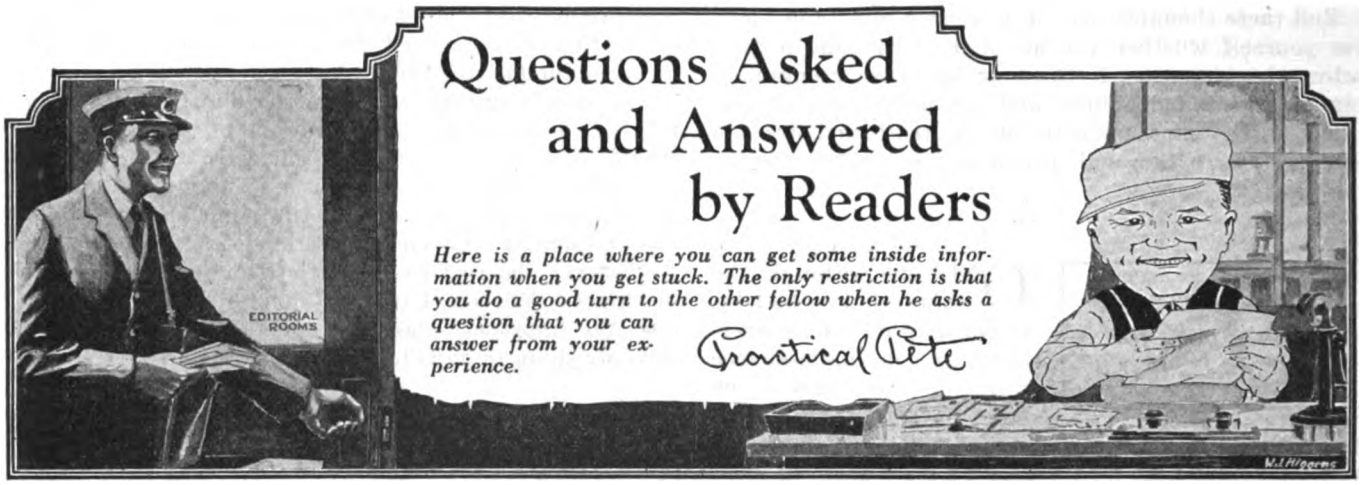
"THE first thing you know you're going to be fired," is an expression frequently passed from one operator to another as a mild way of calling attention to instances of carelessness or oversight. It is sometimes seriously used and sometimes mixed with good humor, but it indicates that someone around the plant has created a reputation for himself of firing men on small provocation.

In this connection we were interested in a recent item which stated that the Frostmann & Huffmann Company of Passaic, N. J., boast that in 1924, although several thousand people were on the payroll only two were discharged. One was discharged because of gross misconduct outside of working hours, and the other because af habitual drunkenness. The causes for these discharges are not so important as the fact that with a strict policy that workmanship in this plant must be as near perfection as possible only two men did not measure up to the requirements that this policy calls for. If this means anything it certainly means that not one man, but a group of men in this plant, must know how to train men and keep them happy enough on their jobs to get them to give to the company the best they possess.

In this plant it is said that a discharged workman is out for good and that it is well known by all who are employed that the plant is hard to get into and hard to get out of. In other words, there is a good place for every earnest and conscientious workman, and just so long as he gives to the company loyal and efficient service, he need not worry about being fired. Such a state of mind on the part of employes reflects itself in the quality of the product they produce and counts more in competitive selling than all the shrewdness of making a product that will sell on competitive price comparisons.

In the last analysis, every manufacturing or industrial works puts into its product three things: raw material, perfection in workmanship and reliability in the service it performs. With good material to start with, brains and the conscientious application of mechanical skill on the part of workmen are the only safe insurance for certain delivery of the other two essentials. This insurance can never be purchased with dollars alone, but around the idea that a plant is hard to get into and hard to get out revolves a plan in the hiring and firing of men that every plant superintendent can study with profit, both to himself and to the organization of which he is a part.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Method of Drilling Holes Through Plate Glass—I have to drill some holes in plate glass ¼ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.
Little Rock, Ark. M. J. J.

* * * *

Method of Turning Commutators—I would like some pointers from readers as to the best way of turning commutators in a lathe. What size and shape of cutting tool should I use for the roughing cuts? Will this same tool be satisfactory for the finishing cuts? What is the best cutting speed? Would you recommend using sandpaper to give a final polish to the commutator or do you depend on the lathe tool to give the final polish? I shall appreciate any other details about turning commutators that readers can give me.
Hammond, Ind. H. H.

* * * *

Where Does a Lineshaft Usually Break?—Recently a 4 3/16-in. shaft broke underneath the hub of a 36-in. pulley sheave carrying eight 1 1/4-in. ropes. Several millwrights have told me that a lineshaft always breaks in the hub of the pulley, but none of them could tell me why. I should like to know if other readers have had a similar experience and if they can give any explanation of why the shaft breaks in this location. I am anxious to avoid a repetition of this trouble, if possible.
Chicago, Ill. R. C. M.

* * * *

Will Two A.C. Motors Operate Satisfactorily in Parallel?—We have a turntable driven by a variable-speed, slip-ring a.c. motor. This motor is too small and rather than incur the expense of buying one motor that is large enough to handle this job, we are considering buying another motor, a duplicate of the present one, and connecting it directly to the table, so that the two motors will both drive the table in parallel. Will the motors operate satisfactorily in parallel? Can we operate both motors from the same secondary resistance and controller, or should we use two drum controllers and two independent resistances? I will greatly appreciate any information and experiences that other readers can give me on this subject.
Omaha, Neb. G. C. B.

* * * *

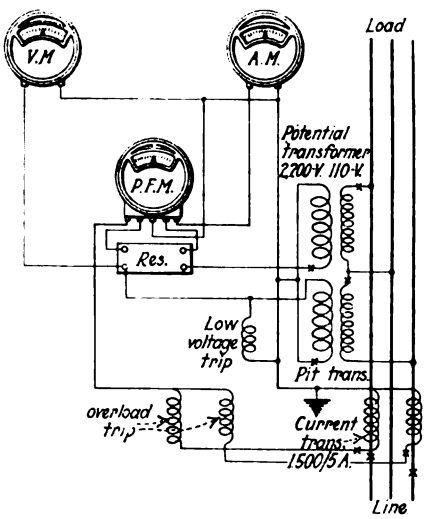
What Kind of Wire Should Be Used Here?—We are having considerable trouble from grounds and shorts due to the insulation failing on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery, and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinary rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?
Tulsa, Okla. L. A. N.

* * * *

Increasing Thickness of Slot Insulation.—I have a 3-hp. Allis-Chalmers induction motor that is connected two-parallel star. The motor has 48 slots and 48 coils consisting of 25 turns of No. 16 double-cotton-covered wire and is rated at 220 volts, 9 amp., 1,200 r.p.m. This motor gets very hard service, although the load is not excessive, and I would like to decrease the size of wire in it. What change would have to be made in the pitch if No. 17 double-cotton-covered wire were used to get more insulation in the slots?
San Diego, Calif. E. A. F.

* * * *

Why Do These Meters Not Register?—We have a Weston power factor meter, Model 356, serial No. 790, and a Weston ammeter, Model 156, serial No. 43008, mounted on a switchboard manufactured by the Condit Manufacturing Co. and connected as shown in the diagram. The connections from the switchboard to the current and potential transformers were made by my



workmen. The polarity marks on the transformers are as indicated. The ammeter reads zero when power is flowing through the switchboard. The power factor meter likewise remains in the same position as when power is off the board. Is the connection scheme shown in the accompanying drawing correct? If so, what do you think is wrong and what tests should I make to locate the trouble? I shall greatly appreciate any advice that our readers can give me.
Sharon, Pa. C. F. C.

Answers Received To Questions Asked

Stopping Breakage of Gears.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. Would a coupling having shear pins do the trick? How could I make such a coupling?
Tulsa, Okla. L. A. N.

In answer to L. A. N., we overhauled the main drive of the ash conveyor at our boiler plant, putting in new gears, more bearings and strengthening all weak points. We relined the motor sprocket and its jackshaft sprocket; also the drag chain sprocket. This is a flight conveyor with flights fastened to No. 111 chain about every sixth link. These flights drag in a chilled cast-iron trough, about 8 in. wide. This conveyor is driven by a 7½-hp., three-phase, a.c. motor with a back gear; the backshaft is connected by a chain to a sprocket four times its diameter, the large sprocket being on the jackshaft. The pinion on the jackshaft is about one-sixth the diameter of the gear on the flight sprocket shaft.

When we realigned the machinery and put in new gears and bearings, it ran only for a day or so before the flight sprocket was crushed. The only way that we could account for the breakage was that a clinker had thrown the flight chain off its sprocket. A new sprocket was put on and everything seemed to be going nicely when another sprocket was crushed. We tried overload relays on the motor, but they could not be set with any certainty because of the vibration of the headhouse. So we decided to use a mechanical safety device to prevent breakage of sprockets.

Accordingly, a spare sprocket for the one on the motor backshaft was bored to a close running fit on the shaft, the hub was turned off on each side, and a band shrunk on it. A keyed collar was made and three holes

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drilled in it; these holes corresponded with holes drilled in the sprocket, on the same circle. Cast-iron pins were selected and a few were machined, but the cost of the machined pins was prohibitive; so we had them cast and a small hole was drilled in each end for cotters. This reduced the cost over 90 per cent. We break on the average two pins per week, but the cost of pins for one year about equals the cost on one sprocket and we seldom have any delays caused by the ash conveyor since it was overhauled.

The only explanation of the sprockets running without breakage before the repairs were made is that the bearings were so loosely fastened as to allow the gears to slip out of mesh when the chain came off. Our reason for drilling three holes in the sprocket and collar were that we could experiment to find the pin that would give the proper strength for pulling an average load and still break before the danger point was reached. We found that a ½-in. pin was the one most suitable in our case. GRADY H. EMERSON.
Ass't. Chief Electrician.
Alabama Fuel & Iron Co.,
Acmar, Ala.

* * * *

Answering L. A. N.'s question, if the dimensions and speeds of the gears had been given, it might be possible to determine whether they are suited for the purpose.

The first idea that presents itself when a gear breaks is to replace it with a stronger one. As the breaking gear in the present case is cast iron, it can be replaced by a much stronger, steel gear. Replacing the cast iron gear with a steel gear would, however, transfer the shock to some other element in the layout; this would probably be the chain which, at the speed mentioned would receive severe treatment. I presume that there was some special reason for the adoption of a roller chain to the service as the speed of 1.800 r. p. m. would ordinarily indicate the use of a belt.

If the sudden great load is momentary, the condition might be met by placing a flywheel on the gear shaft; this would take up sudden fluctuations of the load.

My solution of the problem would be: If the gear were broken, replace it with a steel gear. To prevent the gear breaking, place a flywheel on the gear shaft to reduce the shock incident to sudden "taking hold" of the load.
Los Angeles, Calif. C. O. SANDSTROM.

* * * *

Cost of Changing Two-Phase Motors to Three-phase—The local power company is planning on changing its system from two phase to three phase. This will involve a corresponding change in a large number of motors ranging from 5 hp. to 50 hp. I should like to know if there will be any loss of efficiency in the motors as the result of this change. Also, please tell me the general procedure involved in changing motors from two phase to three phase, what troubles are likely to be encountered and about what the cost per motor or per horsepower will be.
Fort Smith, Ark. V. L. H.

In reply to V. L. H. in a late issue, in changing the two-phase motors to three phase, there will be a loss of between 10 and 12 per cent in horsepower. The current density will remain the same as it was on two-phase operation.

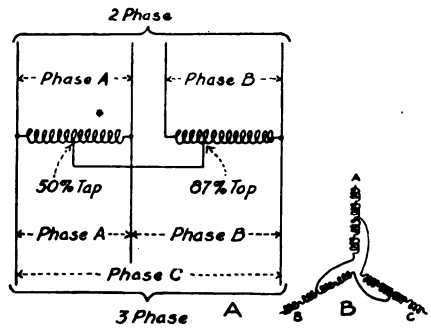
In a two-phase motor there are about 20 per cent more turns in the entire winding; therefore, in making the change to three phase, it would be well to cut out approximately one-fifth of the coils. You must be sure to distribute the dead coils evenly around the motor in order to have it electrically balanced.

If the motors are not fully loaded the loss in horsepower will not be a serious matter and if the work is properly done they should operate very satisfactorily on three phase. U. O. MISNER.
Pioneer Electric Company.
Richmond, Cal.

* * * *

In answer to V. L. H. in a late issue, we have recently arranged to gradually change a large installation of motors from two phase to three phase, in order to make various installations under our supervision flexible in interchange of equipment and be able to purchase motors from stock. Current for this installation is generated at two phase, 440 volts. As a simple solution of the problem we connected two auto-transformers as shown in *A* of the illustration.

As will be seen, we connected the two-phase leads to the busbars at the switchboard and distribute three-phase current over the same feeders which supplied the two-phase motors. If a large number of motors are grouped on one feeder, V. L. H. can connect two auto-transformers to his two-phase circuit at any convenient point in his wiring system and connect the three-phase supply leads to three of the two-phase leads, as shown.



A, two auto-transformers used to obtain three-phase current from a two-phase supply. B, winding of two-phase motor connected star-delta for three-phase operation.

By this method it will not be necessary to change the two-phase motors until trouble develops. Then they can be rewound either for two phase or three phase. Either two-phase or three-phase motors can be connected to the same wiring system provided the proper wires are used for the three-phase motors.

To determine the proper size of auto-transformers a graphic wattmeter chart should be taken from the present installation and a 30-min. average maximum demand obtained. The main auto-transformer should have a capacity of approximately 15 per cent and the teaser transformer 8.5 per cent of this quantity. These percentages are sufficiently accurate for practical purposes.

As an example, if the 30-min. average maximum demand is found to be 100 kva., the main auto-transformer should be of 15-kva. capacity and the teaser of 8.5-kva. capacity. The only cost involved will be the purchase and installation of the two auto-transformers, if the wiring is large enough to carry the three-phase current.

Few, if any, two-phase motors in actual service can be reconnected for use on three-phase circuits without a loss in capacity at the same temperature rating. This is due to the fact that the cross-section of copper and number of turns in a two-phase winding are different from those in a three-phase winding.

Practically all two-phase motors can be reconnected for three phase with balanced voltage, and correct within 5.5 per cent of the two-phase nameplate voltage rating. The output will, however, be about 20 per cent less than the two-phase nameplate rating. To get balanced voltage using all coils, the winding should be grouped for three phase, but instead of being connected in either star or delta it should be connected star-delta by connecting the ends which would ordinarily be connected together in the star winding, to the middle winding of the next group, providing that the middle connection is not within a pole group. This is shown in *B*.

In a six-pole, two-circuit winding, each winding should have two pole groups connected in star and one in delta. It will take a winder from four to six hours to make this connection.

From observation it appears that at least one of the large manufacturers of motors has practically standardized on full-pitch windings for two-phase motors and approximately 85 per cent of full pitch for three-phase motors. This is probably due to the fact that in two-phase motors, the windings are not interconnected, and currents of higher harmonics are not liable to cause serious trouble with the winding. With three-phase windings, however, and especially delta-connected windings, there is a possibility that the motor may be seriously affected by the current of the third and perhaps other harmonics. By chording the winding at approximately 85 per cent of full pitch, this harmonic current will be either eliminated or sufficiently reduced to prevent serious effect on the winding.

For this reason if a two-phase motor, which is wound with the full-pitch winding, were connected with a star-delta connection outlined in the preceding paragraphs, there is a possibility of the delta portion of the winding having a circulating current of the period of the third harmonic, which would be super-imposed on the power current delivered by the three-phase circuit.

An industrial plant or repair shop should be very careful about making any changes in the winding of motors which will reduce the nameplate capacity or materially change the charac-

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teristics of the motors. Anyone making such changes should have a definite and clear understanding with the owner of the motor, so that in case of a burnout there will be no misunderstanding. For this reason it is safe to recommend complete rewinding of motors rather than changing the characteristics by reconnection. Reconnecting from three phase to two phase or *vice versa* can ordinarily be safely done only when the person making the changes is directly responsible for the operation of the motors and knows what to expect in consequence of the change, but is, nevertheless, willing to take the chance. CHARLES R. SUGG.
Atlantic Coast Line Railroad Co.,
Wilmington, N. C.

* * * *

In answer to V. L. H.'s question in a recent issue, perhaps the following suggestions will help him to solve his problem. Acknowledgment is made to A. M. Dudley for some of the data.

Normally a two-phase motor has 25 per cent more turns in series in its windings than has a three-phase motor of the same characteristics. Ordinarily it is possible to cut out 20 per cent of the turns in a two-phase motor, leaving them dead, and still have sufficient turns in series for a three-phase winding. There are three methods in common use for changing motors from two phase to three phase. In the order of their desirability they are as follows:

(1) Twenty per cent of the turns of the two-phase winding are cut out and left dead, the motor being operated on 80 per cent of the two-phase turns.

(2) The number of coils is not changed and they are reconnected to give a three-phase winding.

(3) A "T" or Scott two-phase to three-phase connection is used.

When making any of these changes care must be taken to get the phase coils in their proper place, and as this is usually difficult to accomplish it follows that none of the changes is ideal or efficient. Further, it goes without saying that such changes should be attempted only by a first-class a. c. motor winder. From an investment standpoint it is usually better to rewind the motor with new three-phase coils.

If the first method named above is used it must be remembered that the full-load current of a three-phase motor equals 2÷1.73, or 115 per cent of the current for a corresponding two-phase motor. Now for the same temperature rise the horsepower output will be about 87 per cent of that of the two-phase motor. This loss of 13 per cent of the horsepower would, when figured in dollars and cents, pay the interest on the investment for a good many new coils.

By far the cheapest and most desirable way of overcoming the difficulties encountered in changing motors from two-phase to three-phase operation is to install transformers equivalent to about 50 or 60 per cent of the total motor load and then, by means of the Scott transformer connection, the motors can all be operated two phase from the three-phase power supply in a perfectly normal manner.

The average cost of rewinding a stator for a 5-hp. 60-cycle motor is about $50. The average cost of rewinding a 50-hp., 60-cycle motor stator is about $190. Of course, 25-cycle motors will cost more to rewind as they are larger and require more copper. The cost of transformers varies from about $2.50 per kva. in large sizes to $10 per kva. in the case of small units.
Chief Electrician. LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

Replying to V. L. H.'s question in a recent issue, it will be necessary to rewind every motor on the job in order to keep the efficiency up.

It is true that there are methods of reconnecting that can be used as a temporary expedient. However, if you take into account the fact that there are a large number of motors and that the cost of rewinding all of these will be high, to say nothing of the loss of production while the motors are out of commission, it would seem advisable to replace the present service transformers with a Scott-connected, three-phase to two-phase bank and leave the motors as they are. Three-phase motors may be purchased as needed and operated from a separate bank of three-phase transformers. As the two-phase motors wear out or are taken out of service, they should be replaced with three-phase motors so that eventually the entire installation will be operating three phase.

If it is decided to rewind all of the two-phase motors it would probably be cheapest in the long run to make a contract with some reliable repair shop that has the facilities for doing good, fast work.

As to the cost of doing this work, each motor would be a problem in itself, so that a long-range prediction based on the information given in the question would be at best only a guess.
Plant Engineer. S. W. STEARNS.
Gardner Machine Company,
Beloit, Wis.

* * * *

Transformer Draws Heavy No-load Current—We have a 75-kva., 25-cycle, single-phase, 2,200/220/110-volt lighting transformer which draws an excessive no-load current. The primary current with all secondary load disconnected is about 11.5 amp. at 2,200 volts. The secondary voltage is normal at 0, ¼, ½, ¾ and full load. The temperature of the oil is normal. The insulation resistance between windings and between windings and ground is over 50 megohms. What is the cause for this high no-load current?
Hamilton, Ont., Can. J. F. M.

Referring to the question by J. F. M. in a recent issue, he states that the secondary voltage is normal from zero load to full load, and that the temperature of the oil is normal. Assuming that the frequency of the supply is not lower than normal the only apparent reasons for a high exciting (no-load) current would be some looseness or poor contact in the magnetic circuit, poor quality iron in the core, or some inherent defect in design of the transformer. With the modern transformer, the fault or trouble seems more likely to be found in the core through poor iron or construction, rather than in actual design.
C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

How Can This Motor Be Kept From Humming?—Can someone tell me how I can eliminate the magnetic hum of a 30-hp., shunt-wound, four-pole, 400-1,000-r.p.m. interpole motor? This hum is so loud that it can be heard all over a large department store. The following remedies have been tried: (1) Laminated pole shoes supplied with motor were changed for similar shoes of sturdier construction. The laminations in the new shoes were put together under pressure, riveted with bakelite varnish between them and baked. This did not stop the noise. (2) The air gap was increased. This helped somewhat, but caused circuit breaker to open. (3) Cast pole shoes were used, with no noticeable effect. (4) Skewed laminated pole shoes were tried, with no better results. (5) Used pole pieces with wider air gaps on tips. No results. (6) Magnetic wedges were used in armature slots. These helped somewhat. (7) Disconnecting interpoles had no effect. Before the magnetic wedges were tried, if full field strength was applied and the armature turned slowly by hand, with the brushes lifted up, it had a tendency to lock at several points. If rotated faster it would growl. Magnetic wedges almost removed this effect. Two wedges per slot were used, each 1/16 in. thick and insulated from each other. All armature connections are correct.
New York, N. Y. W. L. S.

Answering W. L. S. in a late issue, in view of the remedies that have been applied, it appears to me that the trouble must be in the design of the motor. Usually the cause of humming is of such a nature that the remedies applied to this motor will cure the ailment. The fact that increasing the air-gap and using magnetic wedges helped on this particular machine makes me inclined to believe that increasing the magnetic density of the armature teeth would serve the purpose.

As this is a comparatively small machine, why not install another machine of different design and note the difference in behavior? I would also suggest that you take this matter up with the manufacturer, so that he can not only correct the trouble on this machine, but avoid it on subsequent machines of like design.

A point that must not be overlooked on this motor is the fact that the trouble may be in the machine foundation, together with the natural acoustic properties of the building in which it is located. In this case the trouble could be overcome by supporting the motor on springs, cork, or sand, so as to isolate it from the building. If necessary it could be enclosed in an isolating room with cork or asbestos walls. Furthermore, a check should be made to determine whether or not this vibration is of a mechanical rather than electrical nature.
West Allis, Wis. EDWARD JAMES.

* * * *

Connecting Watt-hour Meter to Three-Wire Circuit—Will some reader please give me a diagram and explanation of how to connect a watt-hour meter to an Edison three-wire circuit? Is a special type of meter required? Why?
Bellaire, Ohio. J. R. B.

In J. R. B.'s question in a recent issue, he does not state whether the meter is to be used on direct or alternating current, nor whether shunts or instrument transformers will be employed. However, in any case it is necessary to employ either a special meter or an ordinary two-wire meter with a special hook-up of instrument

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transformers, to secure correct metering.

Power in a three-wire Edison system is the sum of the kilowatts in each leg of the circuit. It is also to be noted that the current in the neutral is the difference between the currents in the two legs, and the direction of that current depends upon the direction of the current in the outer wire carrying the greater current.

In case an ordinary two-wire, single-phase meter were used (with one potential coil and one current coil), power would be measured in that side of the circuit in which the current coil was connected. If a current coil of a meter is placed in one leg with its potential coil across the two outer legs, correct results would be secured only when the circuits were absolutely balanced, which is an infrequent condition in three-wire circuits. If the current coil were connected in the outer wire carrying the larger current, the meter would total too many kilowatt-hours while if it were connected in the other leg of the circuit it would not record the entire consumption. In case a two-wire meter were used with the potential coil connected across the neutral and an outer wire, the meter would in no case be correct and would meter only half the energy consumed were the load exactly balanced.

It may be seen from the above that it would be possible to meter a three-wire Edison circuit with either two two-wire meters with potential coils connected across the neutral and respective outer legs, or by the use of a special meter with one potential coil and two current coils acting on the same disc. This is the type of meter used in such circuits when a self-contained meter is used and its hook-up is shown in *A* of the diagram. In this three-wire meter each current coil in conjunction with the potential coil exerts a torque on the meter disc proportional to the kilowatt demand in the leg of the circuit in which the current coil is connected. The coils are so connected that the torque from each current coil turns the disc in a forward direction and each coil acts independently of the other. In case current transformers are used in an alternating-current circuit, a two-wire meter may be used providing the meter and transformers are connected as shown in *B*. If standard current transformers and an ordinary 5-amp., 110-volt, two-wire meter are used with the register correct for the meter when used as a self-contained, 5-amp. meter, the readings on the register should be multiplied by a constant equal to (2× current transformer ratio). A much better plan would be to advise the manufacturer of the meter of the size, type, and serial number of the meter used, as well as the current transformer ratio and connections. The manufacturer could then furnish a direct-reading register. In case the meter is used on a three-wire, direct-current circuit with shunts, a hook-up is given in *C*. Either a special register or a special register constant should be used in this case. An explanation of how to determine the register constant would be rather long and complicated, without more specific details.

Toronto, Ohio. HERBERT KING.

* * * *

Voltage Rating of Lamps Used for Synchronizing—In synchronizing two 440-volt alternators by using lamps in case the synchroscope should fail, what voltage rating of lamps should I use, and how many of them? Should I provide lamps enough for 880 volts or 440 volts?

Indiana Harbor, Ind. A. R. D.

With reference to A. R. D.'s question in a late issue, the number of lamps to use for indicating synchronism is determined by the voltage of the generators. In synchronizing the two 440-volt alternators I would advise using four 220-volt lamps, because at certain instants the two sources of power will be 180 deg. out of phase and double the normal voltage will be impressed on the lamps.

Plant Electrician, Felberg Mahogany Co., New Orleans, La. OVIDE C. HARRIS.

* * * *

In answer to A. R. D. in a late issue, he should use four 220-volt or eight 110-volt lamps, which should be connected in series. This will give a lamp capacity of 880 volts, which is the voltage between two 440-volt generators when they are running 180 deg. out of step with each other.

Hopewell, Va. R. M. BUSH.

* * * *

Answering A. R. D. in a recent issue, the number of lamps used in a group to indicate synchronism is determined by the voltage of the alternators. With high-voltage generators it is not advisable to use a large number of lamps for synchronizing; it is better to use a transformer giving 110 volts on the secondary.

The greatest voltage impressed on the lamps will be double the normal voltage of the transformer or generators. Thus, the maximum voltage impressed on the lamps when two 440-volt generators are being synchronized is 880 volts.

The dark period of the lamps may be shortened by impressing on them a voltage higher than their normal rating. For example, in synchronizing two 440-volt generators, seven 110-volt lamps may be used, connected in series.

Riverside, Calif. PHIL D. COMER.

* * * *

In replying to A. R. D.'s question in a late issue, it may be well to state the conditions for synchronism: (1) The voltages of the incoming machine and of the bus must be equal but opposite in direction. (2) The voltages must be in phase.

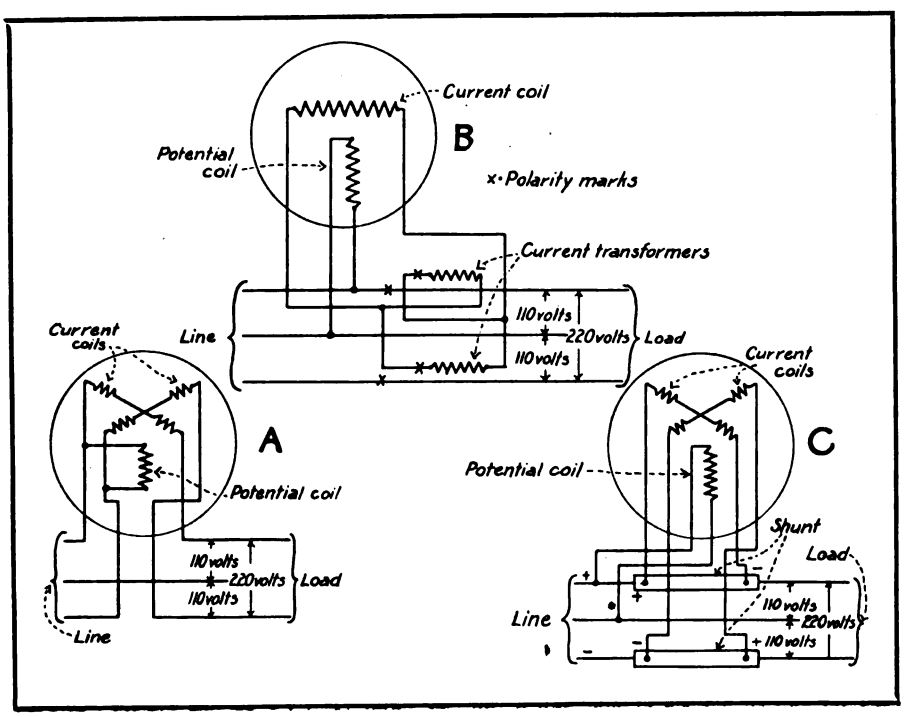
When synchronism between the incoming machine and the bus is detected by the lamp method, it is necessary to have sufficient lamps in the circuit to withstand twice the synchronizing voltage. Thus, in synchronizing with a 440-volt bus it is necessary to have lamps for 880 volts connected in the circuit. However, this may be reduced to one 110-volt lamp by employing two transformers (for single phase) having a ratio of 8 to 1 (880 volts to 110 volts).

The reason for using sufficient lamps for twice the synchronizing voltage is because the voltages of the two machines may at some period be in phase, but in the same direction; hence their effective values will add, resulting in 880 volts across the lamps.

FREDERICK E. NIMMCKE.
Brooklyn, N. Y.

* * * *

Answering A. R. D. in a recent issue, when synchronizing two 440-volt alternators by using lamps, in case the synchroscope should fail, it is assumed that the potential transformers are either not available or that the instrument has a 440-volt winding, making the use of potential transformers un-



Connections for metering Edison three-wire circuit by means of, A, special meter, B, two-wire meter with special connection of current transformers and, C, direct-current meter with shunts.

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necessary. Under these conditions lamps must be provided for 880 volts; that is, eight 110-volt or four 220-volt lamps should be used.

When the alternators are in phase and in synchronism the voltage across the lamps used for synchronizing will be zero and the lamps will be dark, assuming that the dark lamp method of synchronizing is used.

Suppose, however, that the alternators are running at the same voltage and frequency but are 180 deg. out of phase, the maximum degree of displacement. The resultant voltage will then be double the normal line voltage and consequently there must be a sufficient number of lamps in series to withstand this voltage.

It rarely happens that two machine voltages are exactly the same, but in any event the resultant voltage with the two machines 180 deg. out of phase will be quite close to double the normal line voltage.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

Referring to A. R. D. in a late issue, in the process of synchronizing, the circuit is arranged with the two alternators and lamps in series, the lamps being across the switch.

As each alternator is delivering 440 volts, it is obvious that there is a possibility of getting a circuit of two electromotive forces opposing each other, like two batteries in parallel, plus connected to plus, and negative connected to negative, the only difference being that with batteries the electromotive force is constant, while with the alternators it is changing at the rate of 120 times per second on a 60-cycle circuit. Considering one instant in one cycle of the alternators for comparison with the batteries, there would be zero voltage on the lamps when the voltages are opposing each other which is, of course, when the plus terminal is connected to plus, speaking of the instantaneous values. This is the time to close the switch—when there will be no current flow from either machine to the other, as in the case of the batteries.

With vectors, it is obvious that a voltage of 440 opposing 440 gives a resultant voltage of zero, because they are equal and opposite and the alternators are in phase, synchronized with each other. When the alternators are out of phase by the maximum amount of 180 deg. the effect is like reversing the plus and minus wires of the batteries and the voltages then add up, because they are in series with the lamps serving as a load in a series circuit. Consequently, as the total voltage would be the sum 440 plus 440, or 880 volts, the lamps must be arranged to stand that much without burning out.

If the lamps were used with the synchroscope, they would be bright when the synchroscope hand is down, and dark when the hand is up on the zero point, each revolution being one cycle difference in the frequency of the alternators to which the synchroscope or lamps are connected.

Boston, Mass. EDWARD A. GIBBS.

A. R. D. whose question appeared in a late issue, should make use of potential transformers if these are employed for relays, meters, or other instruments in connection with his alternators. The secondary voltage of the instrument transformers will determine the lamp voltage. The rated lamp voltage should be double the pressure which would be impressed upon it if used across but one source of potential.

In synchronizing the voltage from one machine alternately neutralizes and augments the voltage from the other machine, thus causing the lamps to become dark and bright in turn. Depending upon the connections, the alternators may be synchronized when the lamps are dark or when they are bright. It is more desirable that the transformers may be thrown together in the middle of the dark period as it is much more easy to judge this time than it is to tell when the point of maximum brightness is reached.

If the secondary voltage of the potential transformers is 110 volts, then two 110-volt lamps in series should be used. One of the lamps is used only for resistance, and so may be mounted on the back of the panel.

D. W. BLAKESLEE.
Electrical Engineer,
Jones and Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Operating Direct-Current Motor as Generator—We have a Century Electric, compound-wound, d. c. elevator motor rated at 220 volts, 52 amp., 1,200 r.p.m. which we wish to use as a generator to deliver 110 volts, 50-60 amp. I shall appreciate it if some reader will tell me whether it will be necessary to rewind or reconnect the armature, or if there is any way in which we can operate it as it is.
Caguanay, Que., Can. C. R.

In reply to C. R., I would advise you to parallel the shunt fields and leave the series field and armature just as they are. The armature and series field will carry the current that you wish, 50-60 amp., just as well at 110 volts as at 220 volts.

Drive the armature at about 700 r.p.m. instead of 1,200 r.p.m. This will cut the voltage very nearly to 110. Then by using a rheostat in the shunt field you can adjust it to suit your needs. NICHOLAS J. WEISS.
West New York, N. J.

* * * *

Answering C. R.'s question, he can secure the results he wishes by arranging the shunt field in two parallel circuits, reversing the series field and driving the motor at approximately 800 r.p.m., in the same direction that it now runs.

If this motor is "elevator rated" at 52 amp. it is possible that it will not carry a load of over 30-35 amp. continuously. The brush holder may have to be shifted a few bars towards the direction of rotation.

Seattle, Wash. W. MONTELIUS PRICE.

* * * *

C. R. might try driving his elevator motor at 600 r.p.m. with the compound field winding cut out and the shunt fields connected in parallel, if the motor is bipolar or in series-parallel (two parallel sets of two in series) if it has four poles. Under these conditions, the machine should show an open circuit voltage of 110 volts, but it may not hold this voltage when he applies the load. In this case, try shifting the brushes against the direction of rotation, if commutation is satisfactory.

Should this expedient fail to make the voltage hold up with increasing load, C. R. will have to experiment with the compound field. First, connect this in circuit so as to assist the shunt field and closely watch the voltage when the load is gradually applied. The field may prove to be too strong, in which case the voltage will build up higher than he wishes. This will necessitate removing a few turns from the series field coils. By a little experimenting, C. R. should be able to get the series field adjusted to give the proper voltage.

If it is not desirable, or is impossible, to run the machine at 600 r.p.m., it will be necessary to reconnect and probably rewind the armature. In order to advise him on this point more detailed information as to the design of the motor would be necessary.

Gurney Elevator Co., J. M. WALSH.
New York City.

* * * *

Referring to C. R.'s question, probably the most satisfactory results would be obtained by rewinding the armature and fields, if it is desired to use the motor permanently as a generator. Since the load will be only 50 to 60 amp. at 110 volts, and the motor is now rated at 220-volts, 52 amp. it would have approximately the desired output by driving it at a lower speed, say about 600 r.p.m. or at the speed, as determined by test, required to give the correct voltage. If the machine can be belted to the driving motor or other prime mover a test would readily show what size pulley should be used to give the required operating speed.

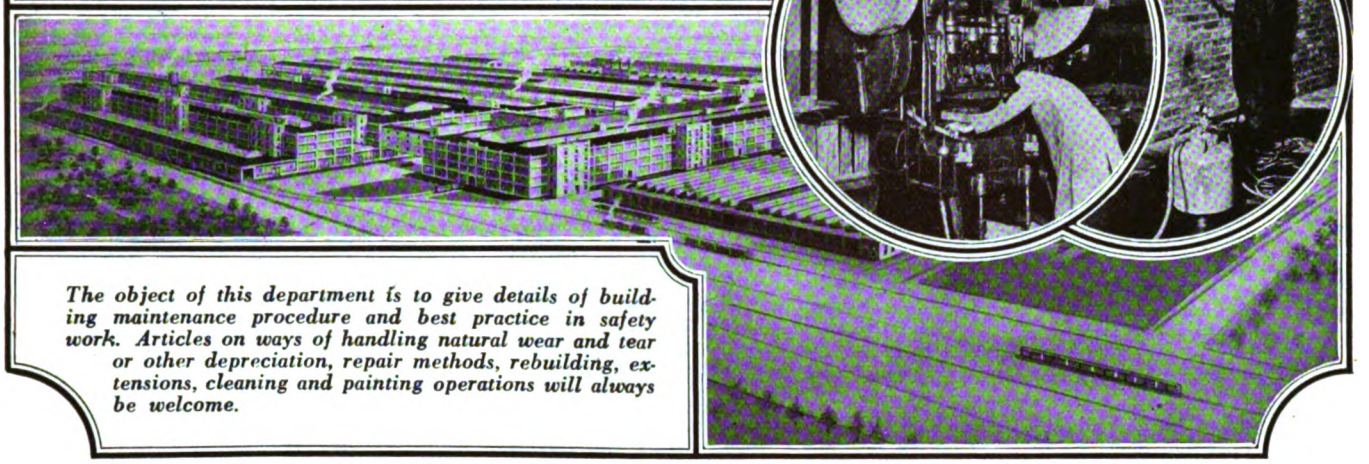
As elevator motors have a very strong series field which is usually short-circuited or cut out when the motor is up to speed, it will be necessary to cut the series field out altogether when the machine is used as a generator, or install a shunt for it, since there would be difficulty in holding constant voltage if the field were left as it now is. The method described above is a makeshift which will require the least expense and the least number of changes. The shunt fields must be reconnected so as to give approximately the same field current as for the full-voltage condition. This would mean two fields in parallel for a two-pole motor, or two in series with two groups in parallel for a four-pole motor.

If it is desired to maintain the speed at 1,200 r.p.m. additional resistance can be inserted in the shunt field circuit to cut down the field current to give half voltage. A shunt will also have to be placed across the series field to weaken it sufficiently.

If the motor is of the non-commutating-pole type it will probably be necessary to shift the brushes, when acting as a generator, in the direction of rotation. C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Odd-Time Uses of Welding and Cutting Outfits in Industrial Plants

THERE are many industrial organizations whose maintenance departments own welding and cutting units. Practically any installation which has been in use for any length of time has repaid its cost many times over in repairing or rebuilding broken parts such as cracked frames, worn and broken gear teeth and other parts of machines, with the consequent prevention of serious and costly shutdowns until new parts could have been made or received from the manufacturer.

Breakdowns, however, occur infrequently and such equipment, if used for repairs only, is idle part of the time. Also, other work must be found for its operator when he is not employed on repairs. Welding and cutting equipment has a much wider use, however, and the progressive plant man can find many other applications which can keep the welding outfit and its operator busy. A simple application, for example, is the fabrication of gear, chain and belt guards, not as a business, but for use about the plant. Of course, such equipment may be purchased complete, but practically always must be made to fit. If it is built in the shop scrap sheet, pipe and wire mesh, or expanded or perforated metal can often be used.

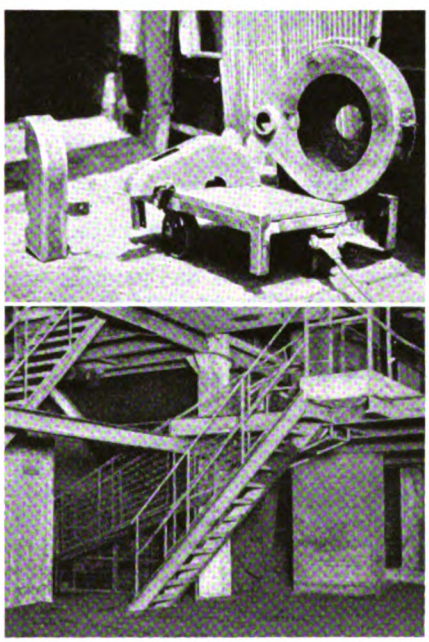
One example of this is the fabrication of a guard for a small gear or a grinding wheel by means of an oxy-acetylene outfit. The usual method of making this in the shop is to lay off dimensions on the sheet steel to be used and draw any circles with a compass made from a piece of chalk on a string. It is a job of only a few minutes for the cutting blowpipe to trim up the sections of the guard ready for joining, which is most readily done with the welding blowpipe. If any forming is necessary, the metal is heated with the blowpipe and hammered into shape.

Guards of sheet metal are usually made in halves, as shown in an accompanying illustration. These halves are held together and to the machine by angle-iron brackets welded on as shown. Welding makes a stiff, strong, tight guard that will not leak oil.

When guards for large gears, belt or chain drives, conveyors or heavy machinery are required, it is usually best to use a steel framework covered with wire mesh, or expanded or perforated metal. With cutting and welding blowpipes at hand, scrap angle-iron or pipe ¾ in. or 1 in. in diameter can readily be cut to size and welded into a frame. Usually a special layout is not necessary. The operator need only wheel his portable welding unit to the job and erect the guard frame, cutting, fitting, and welding as he builds it up just as a carpenter works wood.

When the frame is in place wire mesh, expanded or perforated metal can be stretched over it and tack-welded in place. Wherever it is necessary to leave openings in the screen this can be done by building a door frame or an open space in the skeleton. The door itself may be made of pipe frame covered with wire mesh. A large guard of this type is shown just behind the stairway in an accompanying illustration. The railings on the stairway and platform are also welded.

In addition to guards there are, of course, numerous other pieces of plant equipment that can be made. The ingenious superintendent who begins to look for new and economical welding applications will find them on all sides.



Examples of safeguards which may be made in a plant by welding. Practically any shop which has a welding and cutting outfit for repair work, can find many other odd jobs to keep the operator and equipment busy. These two illustrations, supplied by The Linde Air Products Co., New York City, show examples of work done in an industrial plant with an oxy-acetylene welding and cutting outfit. The illustration at the top shows guards of the type used on gears and chains. These are usually made of sheet metal and often hold oil into which the chain or gear dips. The illustration at the bottom shows a large belt guard, just back of the stairway in the center. This is made with a welded pipe framework upon which wire mesh is tack-welded.

Ingenious Method of Reconstructing and Erecting Settling Tanks

THE man in charge of plant maintenance, whatever title he may bear, must of necessity be a man of ideas and at times must demonstrate a bit of ingenuity to answer the demands placed upon him. An illustration of this occurred in connection with one industrial plant which required large quantities of water for process purposes. Because the required 750 gal. per min. were not always available from outside sources of supply, it was necessary to re-use all the water possible.

In the process some of the stock was carried away from the wash tanks as

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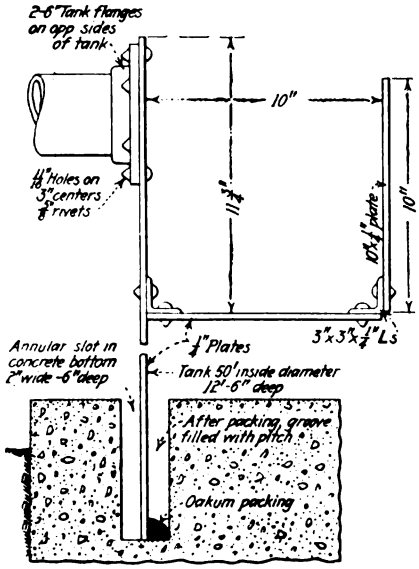


Fig. 1—Construction of overflow and methods of making a non-leaking tank bottom.

These tanks are 12½ ft. deep and were made by cutting in two a tank 25 ft. deep. To prevent the tank leaking, a channel was left in the concrete bottom. This was filled with oakum packing on the inside and then filled with pitch. The overflow gutters are made of plates and angle iron and are fastened all the way around on the inside of the tank. The construction of the gutters and the method of attaching the 6-in. overflow pipe are shown in the sketch. The ingenious tool for punching the 628 holes in the tank which were necessary to attach this gutter, is shown in Fig. 2.

suspended matter. The plant chemist and master mechanic worked out a method of coagulation and decantation which quickly threw down the suspended matter, and clarified the water. The precipitate, which was of commercial value, was saved. To increase the clarifying capacity two steel tanks, 50 ft. in diameter and 25 ft. deep, were cut in half, thus making four tanks each 12 ft. 6 in. deep. How the two additional tanks were set on concrete bottoms is shown in an accompanying sketch, Fig. 1. Because the clear water had at times run over the edges of the tank, the spot around the tank was always wet and muddy. To prevent this an annular trough or gutter, Fig. 1, was placed on the inside at the top of the tank to catch this overflow. Two 6-in. pipes, which were connected by tank flanges riveted to the tank wall, carried away the clear water to the pump pit.

The gutter was of ¼-in. plate with the bottom and sides connected by 3-in. by 3-in. by ¼-in. angles, which were bent to fit the inside circumference of the tank and attached with ⅝-in. rivets, spaced on 3-in. centers. Some 628 holes had to be provided in the wall of each tank in order to rivet the gutter in place. As these holes were 10 in. from the top edge of the tank, the use of a screw-punch was impossible because the usual screw-punch has only a 3-in. throat. To drill 628 holes in each of the tanks, or a total of over 2,500 holes was out of the question. Fig. 2 shows how the device used to do this was made up for use with a tool-steel punch and a pneumatic riveting hammer. With this, three men were able to average about 50 holes per hour in the tank walls.

The row of holes was first laid out and center-punched around the circumference of the tank. The die frame was then placed in position by the set-screws on which handwheels were placed to avoid the use of wrenches. The punch was inserted in the guide bushing and the riveting hammer with a ⅞-in. rivet set was applied to the rounded end of the punch. A bucking bar was held against the other end to steady the die frame.

After riveting the shells and calking the vertical and girth seams, the tank was lowered into the groove in the concrete base. After riveting the gutter in place and cleaning and painting the steel plates with an asphalt paint, oakum packing was placed on the inside and the groove in the concrete was

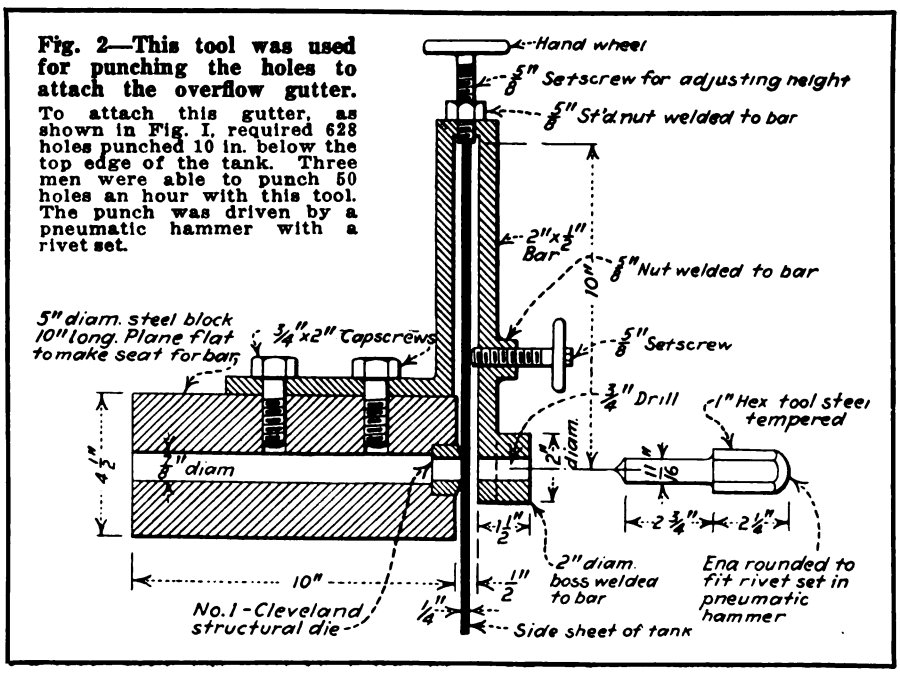


Fig. 2—This tool was used for punching the holes to attach the overflow gutter.

To attach this gutter, as shown in Fig. 1, required 628 holes punched 10 in. below the top edge of the tank. Three men were able to punch 50 holes an hour with this tool. The punch was driven by a pneumatic hammer with a rivet set.

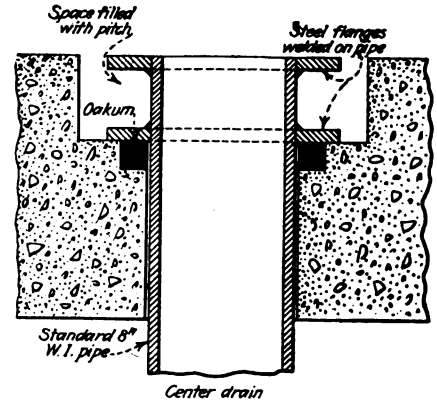


Fig. 3—This drain pipe, which is set in the center of the tank bottom, has not leaked in over a year's service.

filled, both inside and outside the tank wall, with an asphalt compound of high melting point. These joints have remained tight after fully a year of continuous service. The settlings are cleaned out of the tanks very two weeks through the drain in the bottom; the details of the construction of this joint are shown in Fig. 3.

The floor of the tank was waterproofed with a mixture of calcium chloride and flake glue melted and mixed with portland cement. Enough water was added to make the mixture fluid enough to spread with a broom.

Bonne Terre, Mo. H. R. WASS.

Abrasives to Use for Grinding Small Valves

EMERY and ordinary grinding compounds will not do for grinding small valves as they make the surfaces worse than before. A good abrasive material for this purpose is pumice dust. This may be purchased at almost any drug store. Dip the oiled valve in this and lap it in its seat. The pumice will do the work quickly and without scoring.

Pet cocks are another of the grinding jobs that give trouble by scoring. If the average mechanic has a pet cock or any other of the plug valve family to regrind, the chances are that he will turn out a job full of ridges and grooves.

The writer has been faced with this problem many times. One time it was a pet cock in a mill, again a cock on the gasoline tank at a roadside filling station, and so on. Of course, nearly all of these places had some sort of abrasive they knew would do. However, the writer always went to the nearest railroad track and followed along until there was a pile of sand against one of the rails, where an engine had slipped and the engineer had given the wheels sand.

Using a liberal quantity of this, in fact, rolling the well-oiled plug right in it, the grinding commenced. At first, the soft brass seems to be ruined, but soon a surface is produced that will hold any liquid. DONALD A. HAMPSON.

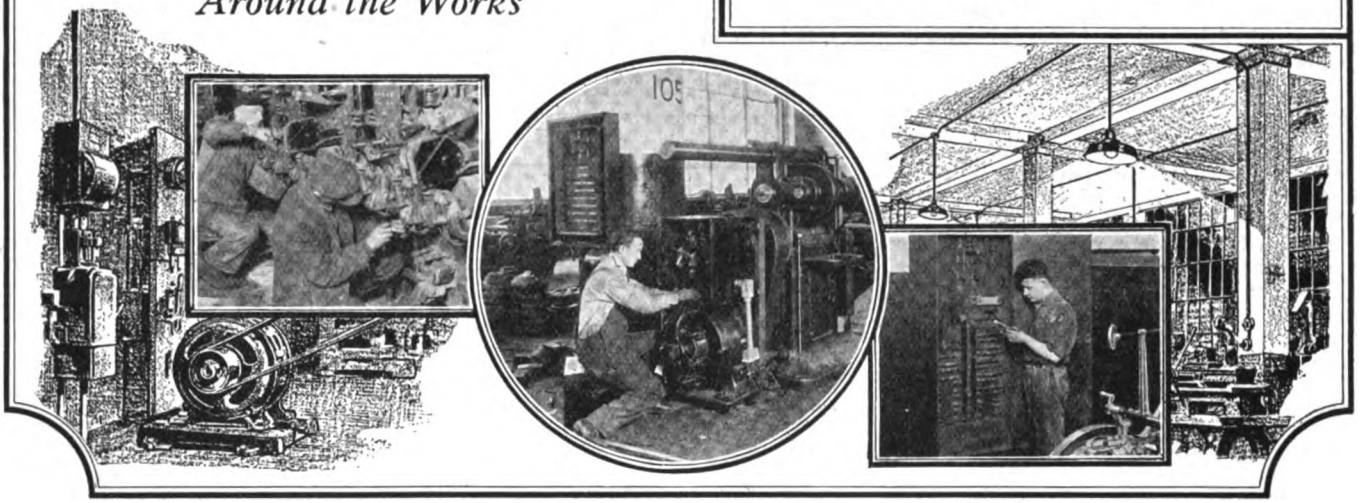
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



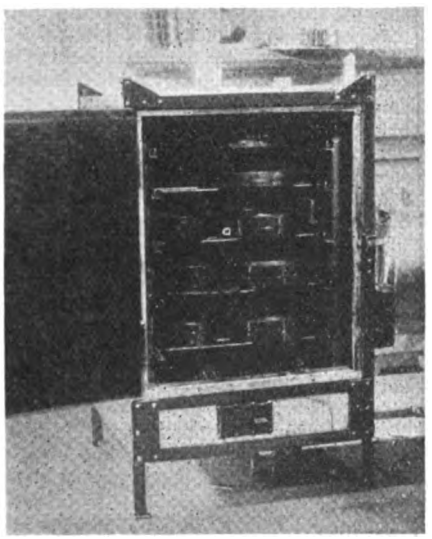
How Electric Baking Oven Speeds Production of X-Ray Machine Coils

ONE of the important problems encountered in the manufacture of X-ray machines is to secure thorough drying of the insulating varnish used on the secondary coils. These coils are wound by special machines and consist of layers of enameled wire ranging in size from No. 28 to No. 36. Strips of oxidized oiled paper are placed between the layers of wire. Each layer of wire is then treated with varnish to give mechanical strength and keep the wires in place. The finished coils have a 3-in. face and vary in diameter from about 8 in. to 16 in.

Formerly these coils were allowed to dry in air, but this took a long time and one could never be certain that the varnish was entirely dry. Consequently, it was necessary to work about three months ahead on our coils in order to insure that they would be as nearly dry as possible when they were finally assembled in the machines. Wet or "tacky" varnish is not only a poor insulator, but in time it will attack the enamel on the wire and destroy its insulating value.

The use of an electric oven for baking the coils has eliminated this uncertainty and enabled us to cut down our stock of finished coils. Now, after the coils are wound and taped they are placed in the oven, which was made by the Westinghouse Electric & Mfg. Co., and baked for 24 hr. at a temperature ranging from 150 to 170 deg. F., after which they are ready for use.

Electrical Engineer, W. S. WERNER.
Kelley-Koett Manufacturing Co., Inc.,
Covington, Ky.



Secondary coils for X-ray machines are baked for 24 hr. in this oven. Formerly they were allowed to air dry for about three months.

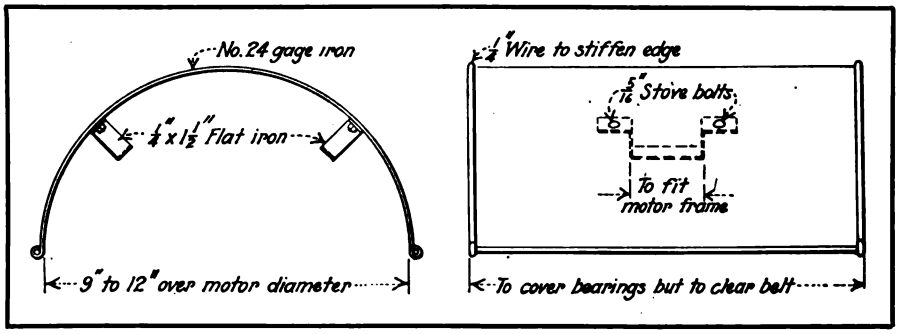
Removable Shield Which Protects Motors From Dripping Moisture

MOTORS operating in paper mills, dye houses and other similar places, where they are subjected to the drip from condensation on ceilings or water pipes, may be protected by using a special hood or helmet which sets on top of the motor. The attachment shown in the accompanying sketch is sufficient, we have found, to shield the motor under such conditions. In addition, it does not occupy additional floor space or interfere with sweeping around the motor. It will stay in place under any conditions, although it is easily removable when occasion requires.

As is indicated in this sketch, the brackets supporting this shield are more particularly adapted to the open-frame type of motor, but by the proper change in the flat iron brackets the shield can be easily adapted to other types of motors. The brackets ordinarily are made about ¼ in. shorter than the distance between the side frames of the motors. A clearance of about 9 in. between the motor and the shield for motors up to 25 hp. and a 12-in. clearance for motors up to 75 to 150 hp. is ample for ventilation. This shield is made of 24-gage sheet metal stiffened at the edge with a wire, as shown in the sketch, which makes it sufficiently rigid and substantial so that it will stand hard usage.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

A removable helmet or shield, such as this, protects the motor from any dripping hot or cold water. If reinforced, as shown, it will also stand considerable rough handling.



Testing Insulation Resistance Reduces Shutdowns

THE condition of the insulation of several of our rolling mill and mine motors and generators is of great importance to us because of the

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continuous service that is required of them; particularly so, in view of the fact that we have them insured against damage and carry use and occupancy policies.

A little over a year ago we decided that in order to obtain the full benefits from our insurance we should carry out a rigid inspection of the important units once a month. This inspection was to be the same as the one performed by the insurance company's inspector three times a year.

We decided that it would be impossible to use a high-potential test to determine the dielectric strength of the insulation because of the danger to the old machines, their location, and various other factors well known to operators of this type of equipment. It was decided to use a 1,000-volt megger to measure the insulation resistance and to plot curves of insulation resistance for the period of a year, as taken by monthly tests.

In Fig. 1 are shown some of the curves that were taken on a synchronous motor-generator set over a period of several months. Readings were taken on the synchronous motor field, the synchronous motor stator, and the d.c. generator field. As is shown in Fig. 2, the method of making a megger test on these machines is very simple indeed. The ground terminal of the megger is connected to the bedplate or other grounded part of the machine and the line terminal of the megger is then connected to the winding on which an insulation test is to be made.

Fig. 2 shows how a test of the field of the synchronous motor is made. As shown by the middle curve in Fig. 1 the insulation resistance varied from 20 to 18 megohms during the months of January, February and March. In April, however, the resistance fell to 9 megohms.

When the test was made in May the insulation resistance was found to be only 0.4 megohms or 400,000 ohms. We look for trouble on 2,300-volt machines showing an insulation resistance of less than 1 megohm and on 250-volt machines showing a resistance of less than 800,000 ohms. Inasmuch as the field of the synchronous motor is on a 2,300-volt machine, the 400,000-ohm resistance was entirely too low. Consequently, it was decided to make tests on the individual poles of the field of the motor.

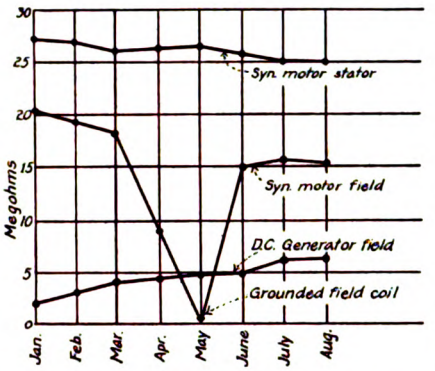


Fig. 1—The data taken from the megger test are plotted as shown.
The drop in the value of insulation resistance in April indicated that something was wrong. The pronounced drop in May caused an investigation to be made which resulted in the discovery of a grounded field coil.

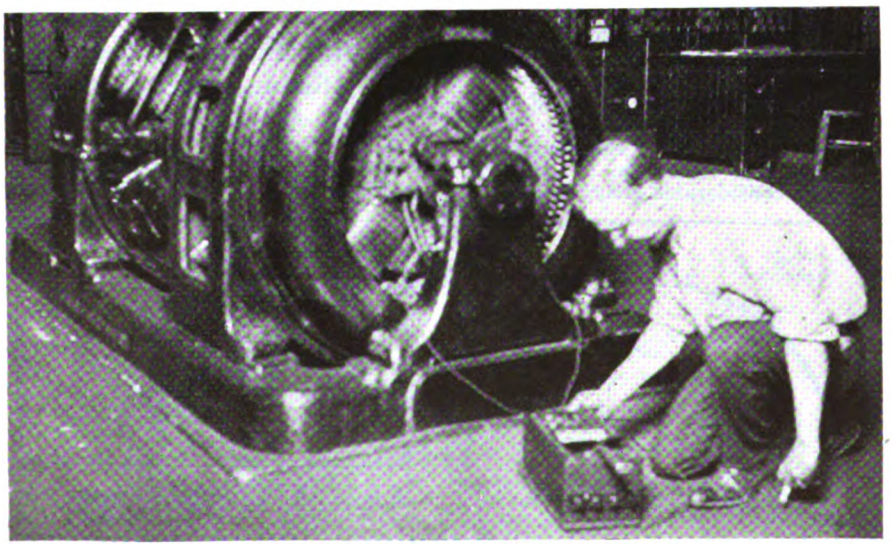
As would be expected, the weak point was found in one of the poles. Upon the removal of the coil from the defective pole, it was found that the inside end of the coil was practically grounded. We were able to replace the field coil and thus prevented a shutdown of this machine at a time when its services were required.

We have been able to discover several cases of defective insulation since this method was put into practice and have prevented at least three shutdowns of important units.

We have found that this method is a very convenient, reliable and safe check on machines of importance. We are now considering a similar check on all of the important 2,300-volt feeders in our plant.

Chief Electrician, J. S. MURRAY.
Follansbee Bros. Co.,
Toronto, Ohio.

Fig. 2—Systematic tests of insulation resistance prevented a shutdown at an inopportune time on this machine.
Tests are made each month and the values obtained are plotted as shown. A sudden drop in the readings indicates an approaching failure.



Causes of Trouble in Operating Motors in Parallel on Bridge of Crane

IF SEVERAL cranes are installed in an industrial plant and trouble with the bridge propelling motors occurs on only one crane, the chances are that the trouble is due to some local disarrangement of the track caused by the settling of the building. This would cause the wheels to bind on the rails so that the motors instead of applying power on the basis of 25 or 30 lb. per ton will be compelled to exert torque on the basis of two or three times this amount which, of course, will unduly overload the motors. Binding of the wheels may also be caused by the wheels themselves getting out of alignment.

If the trouble is not occasioned by undue friction losses it may be due to careless or improper operation.

It should be remembered that the power exerted by the bridge motors on the crane is used in two ways: (*a*) To overcome the friction in the bearings of the bridge wheels, to supply losses in the gearing, and to overcome the windage and all other friction losses. (*b*) To overcome the inertia of the bridge itself.

The power required to overcome the inertia lasts only as long as the bridge is being accelerated, whereas the power required of the motors to overcome friction lasts all the time the bridge is in motion except, of course, when power is shut off and the bridge coasts to rest. With such a heavy structure, the power required under item (*b*) above is often several times the value of (*a*) and since it takes considerable time to bring this up to full speed the motor may be taxed far beyond its capacity, assuming that the controller handle is turned on too fast and there is no means of limiting the current peaks.

Assuming that the accelerating contactors operate by some current-limiting scheme, the relays should be adjusted to keep the accelerating peaks down to a reasonable value, even though this may lengthen the accelerating period somewhat. If, when the relays are adjusted to keep the current peaks down to proper value, it is found that it takes too much time to get the bridge up to speed, the only other alternative is to use larger motors which can exert the necessary torque at starting without injury to themselves. If a definite time-limit scheme of accelerating is used, the timing relays should be set to give a greater period of acceleration.

If there is no automatic device for keeping the current peaks down, it may be found that the operator throws his controller handle around to the "full on" position, which is equivalent to throwing the motor directly on the line without the usual protection obtained by first inserting resistance in series. When accelerating loads of low inertia, this may have no bad effect providing the motors can commutate the inrush of current, since the motors quickly reach full speed and the extra current due to accelerating the load quickly

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falls to zero. In the case of a high-inertia load it is very important that some means be provided for keeping the current peaks down during the long accelerating period.

This should be done by means of accelerating relays. Relays will take the problem of how fast the accelerating contactors should go in, entirely out of the operator's hands.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

Some of the Practical Points to Consider in Selecting Brushes

SATISFACTORY operation of direct-current and slip-ring motors depends, to a large extent, upon the type of brush used; however, a brush which is entirely satisfactory for one type of service may be very unsatisfactory in another.

Some of the more important factors to take into consideration when selecting brushes for any particular application may be obtained from a careful study of the accompanying chart entitled, "General Characteristics of Brushes." This is a slight modification of a chart issued by the LeValley Vitae Carbon Brush Co., New York City, and gives a brief discussion in tabular form of some of the characteristics of a brush, the definition of these characteristics, and their effect on performance.

Comment on "Motor Trouble Traced to Tight Pump Bearings"

I NOTED in a recent issue of INDUSTRIAL ENGINEER an article by Grady H. Emerson, under the above heading, and wish to comment on it to the extent of commending him on the way he handled this pump and motor trouble. Too frequently the repairman who is called does not analyze the action of the different parts and more trouble is caused, which is entirely unnecessary.

The motor mentioned is, as stated, a self- or automatic-starting polyphase motor, only a plain knife switch being necessary to start the motor, as only the high-resistance squirrel-cage winding is used in starting, this giving approximately 200 per cent of full-load torque. The balance of the rotor winding or the insulated winding is thrown into service after the motor gets up to speed and the governor operates, shorting each rotor coil on itself, thereby giving a low resistance running winding.

The short-circuiting segments which are contained in the spring barrel or shell are practically the same as are used on Century single-phase motors and are used to short the commutator bars of the insulated or running winding, and in this manner the additional amount of copper is added to the rotor circuit.

On the smaller sizes of motors, the spring barrel is made of pressed steel which will stand more abuse, but since we have quite a number of the larger motors out, and have not had occasion to supply new spring barrels, this would indicate that the cast-iron spring barrel is strong enough to perform its proper function. I might also state that the same construction is used on the large single-phase, repulsion-induction motors.

Referring to the wearing of one of the rods or governor pins, this is an unusual condition and we are inclined to believe, as stated, that it may have been upset due to the spring barrel being blocked by the broken piece.

In assembling the governor mechanism and the spring barrel at the factory, the governor is first installed and then the spring barrel is pushed back against the pins, and if there is any play in either weight, the other pin is cut off.

The spring barrel can then be moved to its maximum running position to determine whether or not the short-circuiting segments will properly span between the commutator bar and the copper short-circuiting ring just behind it.

In the ordinary manufacturing processes it is practically impossible, although we use drilling jigs throughout, to cut the pins so that it is not necessary to make some adjustment after the spring barrel is installed. We mention this so that it will be understood that if the governor weights are interchanged on the studs, one pin may appear to be longer than the other and inasmuch as it is easier on the job to interchange the governor weights, perhaps two or three times before the right length is obtained, than it is to dismantle them, they are first interchanged to see if this will not correct this condition.

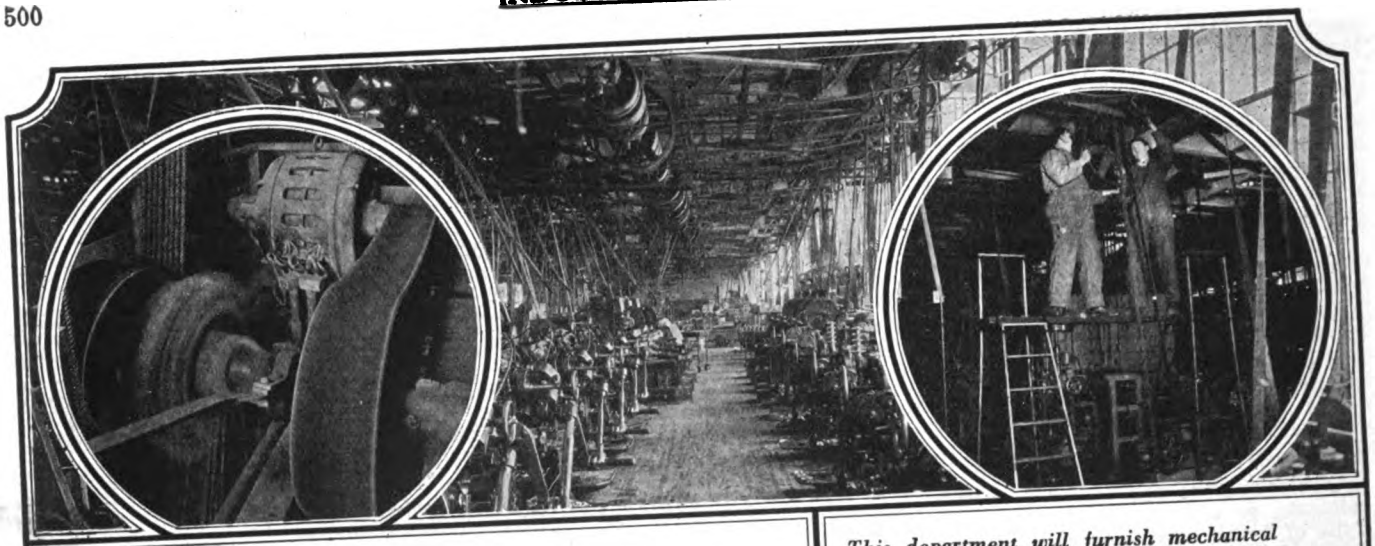
H. S. KELLOGG.

Service Dept.,
Century Electric Co.,
St. Louis, Mo.

General Characteristics of Brushes

CHARACTERISTICS	DEFINITION		INFLUENCE ON PERFORMANCE		
	GENERAL	SPECIFIC	DIRECT EFFECT	VARIATION	REMARKS
Composition	Carbon-Graphite		Hard, slightly abrasive.	Varying with percentage of graphite.	Generally used on flush mica equipment.
	Electro-Graphite		Hard, non-abrasive, low friction.		Used on slotted mica commutators and high speed equipment.
	Natural-Graphite		Soft, more abrasive and higher friction than electro-graphitic brushes.		
	Metal-Graphite		Low resistance, high current capacity.	Varying with percentage of metal contents.	Low voltage work and slip rings.
Resistance	Opposition offered by material to flow of current.	Specific resistance is the ohms per in. cube of material from one face to opposite one.	One of the features which affects current capacity of brush, the higher the resistance the lower the capacity.	With increased temperature of carbon, resistance generally goes down. (Negative temperature coefficient.)	Resistance is not so important by itself as by its influence on capacity and contact drop.
Hardness	Ability of surface to withstand pressure.	Scleroscope hardness is measured by height of rebound of a steel weight dropped from a certain height.	Hard brushes withstand mechanical strains and have long life, soft brushes wear faster but run more quietly.	Smaller percentage of graphite generally increases hardness.	Extreme hardness is liable to cause chipping. Hardness has no relation to abrasiveness.
Strength	Ability of material to withstand mechanical strains.	Strength is given in lb. per sq. in. at which brush breaks under a shearing strain.	Strength must be considered where unusual mechanical conditions prevail.	Carbon graphite brushes show 25% to 50% greater strength than natural graphite brushes.	Strength of brushes depends largely upon the composition and method of manufacture.
Contact Drop	Voltage needed to pass current through point of contact between brush and commutator.	Normal contact drop is the voltage between brush and commutator, when normal current is passing. Total contact drop is the sum of positive and negative drops.	The contact drop voltage opposes the voltage generated by reversal of current under brush known as reactance voltage.	It varies only slightly with density of current and is more or less constant within the range of normal capacity. With increased pressure it goes down at first and then becomes constant.	Non-interpole machines with high reactance voltage should have high contact drop brushes. Interpole machines with reactance compensated for do not need them.
Friction	The force which opposes the motion of commutator as it passes by the brushes.	Coefficient of friction is the ratio between the force of friction and the normal pressure at surfaces.	Friction means heat and wear and low friction is essential.	Coefficient of friction increases with increased pressure on brush and decreases slightly with speed.	Brushes may be treated to reduce friction.
Surface Speed	The peripheral speed of contact surface under brushes.	The maximum permissible speed is given in ft. per minute.	Do not exceed recommended figures; otherwise heating, chattering and chipping may result.	Other conditions being equal the nature of surface of commutator changes considerably with the speed of same.	For slip ring service speed may be increased 25% to 50%.
Capacity	The current a brush can carry without undue heating.	Normal capacity is given in amperes per sq. in. of cross section and permits of liberal overloads.	The carrying capacity must be taken into account in choosing brushes. Normal load or overload may be the determining feature.	Machines with poor commutation and resultant high heating effect of short circuit currents demand higher capacity brushes than interpole machines.	Brushes on slip rings may be rated 25% to 50% higher capacity.
Pressure	The tension of brush spring for best operation.	Normal pressure is given in lb. per sq. in. of cross section of brush.	Lowest brush tension giving good results is desirable.	Pressure affects both contact drop and friction. (*See above*)	Too much importance cannot be attached to spring pressure.

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Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

How Old Double Belts Were Re-used on Small Drives

A MACHINE shop had one planer drive that was particularly hard on belts. This drive consisted of two vertical belts running from the planer counter-shaft overhead to the machine. One of these belts, the reverse, operated at a speed considerably over 6,000 ft. per min. The shop bought the very best 4-in. double belts made especially for this purpose, but the average life of the two belts was only about a year. This short life seemed to be due not so much to the speed as to a separation of plies due to bending and twisting; at least, the fact that the crossed driving belt was the one to go first seemed to prove this. Also, the shift was rapid and tended to wear the edges.

Although the belt was carefully watched and frayed joints or edges were cemented up overnight, finally a loose lap would catch on the fork before it was noticed and tear out a piece of the belt. After two or three pieces were torn out of the belt and the stretching caused several baggy spots, the belt naturally would then be longer in places on one side than on the other, which would cause it to flop over in a permanent twist. By that time, a new belt was cut to length and laced, ready to substitute on a moment's notice. In this way, about 50 ft. of used belt was put away in the belt stores in the hope that there might be some other job where the duty was less severe and on which these lengths could be used or might be useful in patching other planer belts.

Finally, the shop put in a new lathe and needed two 16-ft. belts; 4 in. wide to drive from a lineshaft to the two pulleys on the lathe countershaft. No 4-in. or 3½-in. belt was on hand and the plant did not care to buy any because work was slack. The belt man remembered the old planer belt, which was made of first-class belting material, and decided to use it on the drive to these lathes, which operated over friction pulleys without belt forks. The duty was light in comparison with planer work. From the old belt he cut eight pieces which averaged 4 ft. in length when they were squared off. These were put through the lacing machine and made up into two belts. The joints were all good and solid and, as the belts were not shifted and not within reach of the operator, they gave good service. In making them up, the best side was put next the pulley.

A new 3-in. single belt was put on the vertical drive of the same lathe. This slipped, as all new belts do until they get softened, so much that the operator could not carry on the required lathe work. It was proposed by the lathe foreman to coat the belt thoroughly with oil and let the machine run idle a couple of days to run-in the belt. However, the beltman searched through some more of this discarded belting and picked out several fairly long sections with one-ply in good shape. Ripping off the worn plies, he collected three good, single pieces long enough to make up a belt 24 ft. long.

The single plies were squared off and the ends skived down to make long, lapped joints. Using belt cement, hammering the joints tightly together, and clamping overnight, the belt man had a presentable belt ready in the morning. The two ends were cut off to correct length and wire laced carefully.

This made a belt the full width of the cone pulleys of the lathe and one that was extremely pliable and with a perfect friction surface all ready for the pulleys. It was a little thinner than a regular single belt but the assumption was that this belt had as much actual strength as the ordinary single belt because it was made from a higher grade of material. This belt proved to be most satisfactory on the lathe. The pulleys on the lathe were a bit narrow for a 3½-in. belt, and so in narrowing up this old planer belt, it was cut to 3¼ in. wide. This provided a more powerful drive than would have been the case if the nearest size had been used that would run freely on the cones.

How Machine Shafts Get Bent in Assembling

WHEN setting up machinery in the field or assembling tightly fitted parts without a press, a little carelessness may easily undo all the careful machine work that has preceded. This usually comes from driving the shafts into gears or pulleys or in special construction. Often the only way to do this is to use the sledge. While this method is to be deplored it often has to be done, nevertheless. It is entirely possible to drive a shaft without battering the end, but the most serious trouble comes from hitting the shaft on a slight angle instead of squarely. If the blow has a sufficient angular moment to overcome the elasticity of the steel, the shaft will be bent.

On many shafts which have been driven in, when put in the bearings, the mechanic has found that the shaft does not turn freely or that the assembled parts run out of line so badly that the job has to be "shopped" for straightening and for additional repairs. In many of these cases, the workmen do not understand how the shaft got bent and blame the trouble on poor shop work.

Shafts that have not had the end trued in a lathe are the unsuspected causes of much of this trouble. A good "striker" can hit the end of a shaft squarely, but he cannot hit the end of a shaft that is sawed at an angle of 1/16 in. without bending it. Whether it takes a permanent set or not depends upon the relative force of the blow and the resistance of the steel.

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Method of Checking Parallelism of Shafts on a Chain Drive

OF THE two ammonia compressors that are chain driven from Allis-Chalmers motors in an ice cream factory, one has always run well but the drive to the other had given trouble for years. According to the operating force, this machine was classed with multitudinous other installations of machinery that "have never been right since they were set up." Each man who had taken the job of engineer had run the gamut of slack chains and tight ones, shifting the sprockets so that they "lined up better," taking out, or putting in a few links of the chain, leveling the motor, and so on. However, the chains frequently broke, or jumped, and were noisy.

An amusing incident of one of these efforts was the attempt of one engineer to shorten up the lower run of the chain and put the excess on the top run. This man counted links, punch-marked the sprockets, and got the manager enthusiastic over the plan. "My idea," he said, "is to advance the chain three links on the driven sprocket, but leave it at the same place on the motor sprocket. If I can keep it there, I will have the slack out just after the crank passes the dead center each time and there won't be that slap to the chain that breaks it."

Needless to say, when the fireworks died down the sprockets and chain had settled those important details automatically and resumed their old relation.

The last man on the job got tired of replacing broken links and insisted that the installation was out of line. However, he preferred to have someone else with more experience go over it. An expert mechanic was called in, looked over the machine, made some measurements and "went back to the shop for tools." He returned with a long straight-edge, a level, some shims, and a ball of twine. The motor did need a little leveling up, but the amount was not enough to cause chain trouble. The long straight-edge was placed against the edges of the large sprocket on both sides. Tests indicated that the driving sprocket centered very well. Previous to this, he had clamped a piece of steel against a guard and ascertained that the driven sprocket ran true on its edges.

These details settled, the remaining step was to find whether the shafts were parallel. Here he was stuck. The 50-hp. motor had a 50-in. shaft with no place longer than 6 in. to line it up by. It was the typical situation with a motor installation; the wonder is that they are as good as they are, for a man really has nothing to work from. The accompanying drawing shows the essential details but, for obvious reasons, the drawing is not to scale. The sprocket lined up with the driven sprocket. The outboard bearing of the crankshaft was 11 in. in from a line at the front end of the motor.

The experienced eye of the mechanic told him that the motor was not parallel with the compressor, but a careful examination of the motor, even to scraping away some paint, showed that no machined surfaces were available for checking. To run a line was a hopeless task. He pried off the sheet metal cap at the front end of the motor frame to see if the shaft center was available. He then returned to the shop to make the tool shown at the right in the accompanying sketch.

This tool was made from an 8-ft. piece of ¼-in. by ¾-in. drawn steel. It was twisted at right angles about two feet from one end and a 5/16-in. hole was drilled near the other. A piece of steel was pointed in the lathe to fit the center holes in the motor shaft, turned to fit this 5/16-in. hole and riveted in.

The twisted end of the bar of steel was then graduated in the shaper vise. The table-feed screw of the shaper had four threads per inch, or a movement of ⅛-in. for each half turn of the screw. A series of lines or graduations, all of the same depth, ⅛ in. apart, were cut with a V-pointed tool by lifting the tool while the feed handle was turned first to the top and then to the bottom. A length of 8 in. was graduated in 10 min. with a passable degree of accuracy.

A line was run with a square across the bar from the last graduation and brought to the opposite face. Using this for a starting point, a similar graduation was cut on the opposite side.

Finally, steel stamps were used to number each inch of graduation on both sides with its distance from the cone point. Thus, the bar could be used either side up and the graduations would read true from the center of the motor. As the lines were cut clear across the ¾-in. side of the bar, a reading could be made on either edge or by a tool laid across.

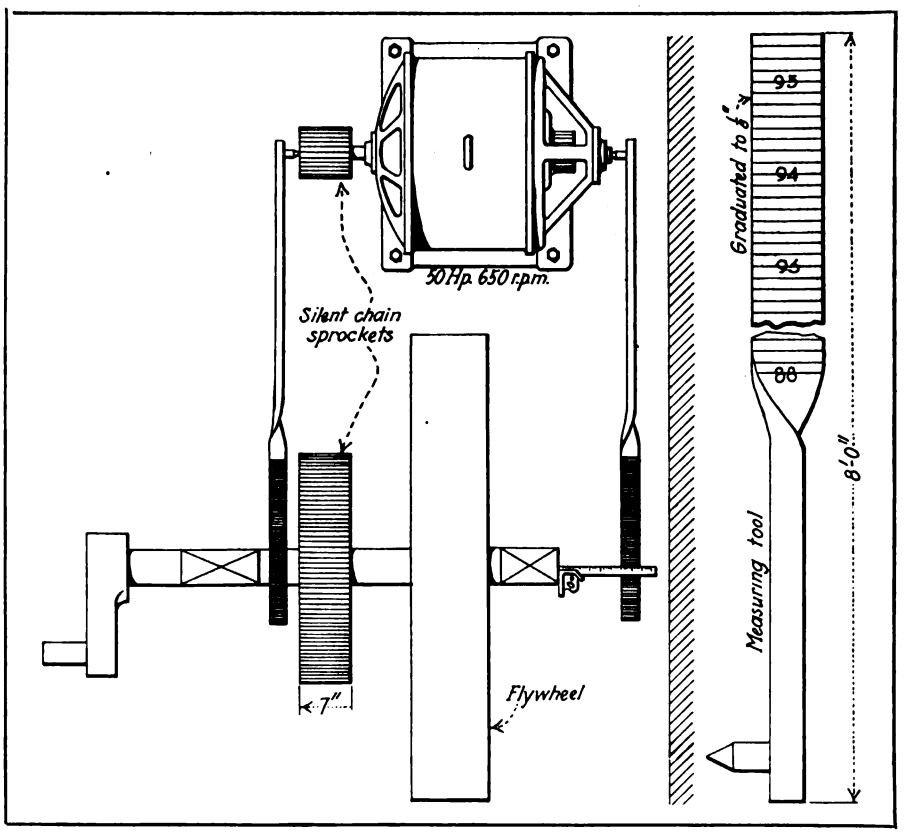
It took nearly 2 hr. to make this tool. Many millwrights might argue that this was an unnecessary expense. On the other hand the units had been lined up with the general tools of the craft a number of times and the results were very unsatisfactory. What the special tool disclosed was startling enough to warrant any expense.

In using this measuring tool, it was first necessary to strike a vertical center line on the outer end of the crankshaft and a line on the top center of the shaft between sprocket and main bearing. These lines were used as reading points against the tool. As the outboard bearing was nearly a foot short, a combination square was placed against the end of the shaft and on the center line. This extended the line to the graduations on the tool.

When the parallelism of motor and crankshaft was checked with this tool, it was found that the shafts were 1 inch out of parallel in the length of the motor. A minor part of this was traced to the skewing around of the motor and rails under the pull of the chain, but most of it was in the original alignment. To correct this, the foundation bolts had to be moved so as to allow sufficient shifting. When pried around to parallelism, a piece of 4-in. by 4-in. timber was put at opposite corners to prevent future shifting under loads or loosened bolts; one of these timbers butted the adjacent bed plate of the machine and the other the concrete wall of the building.

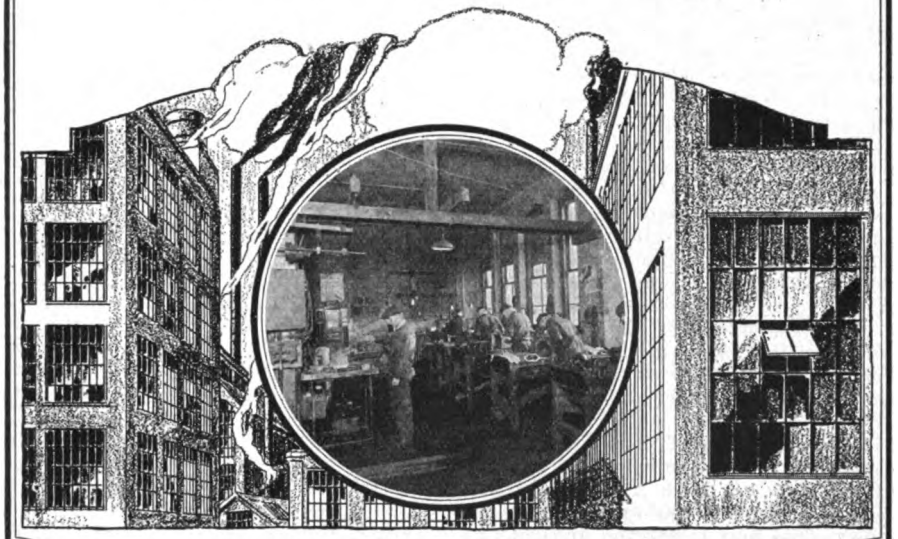
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

By means of the tool shown at the right the motor and compressor shafts were found to be 1 in. out of parallel in the length of the motor.



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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Correction in "Some Practical Pointers and Winding Rules"

IN THE article by A. C. Roe, published under the above heading in the August, 1925, issue an error was made in the first paragraph on page 381 in referring to Fig. 1 *B* instead of Fig. 1 *C*. The corrected paragraph should read:

By comparing Fig. 1 *C*, which shows a right-hand winding, with Fig. 1 *A* it will be noticed that coil *C* is shorted, and that the arrows on slots *1* and *2*, *4* and *5*, *7* and *8*, *10* and *11*, in Figs. 1*A* and 1 *C* are in the same direction. Hence, a left-hand or right-hand coil does not affect the rotation or polarity.

Construction of Foot-Operated Broach for Cutting Plate

SHEARING ⅛-in. and heavier steel plates, is usually done in the small repair shop by drilling a series of holes, spaced closely, and finishing the cut with the chisel. Where plate shears are available or where the work can be done in a shaper, these means are used instead of the drill method because of the time required to cut plate with the drill press.

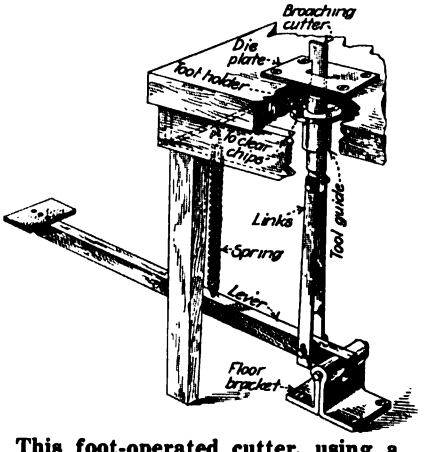
In one small shop, a foot-operated shear or cutter was made up as indicated in the accompanying sketch. While intended for temporary use, the fixture was such a success that it was adopted for a considerable amount of plate shear work and is used to gash or sever the plate, wherever any straight-line cutting work is required.

The tool or fixture was made for foot operation; a piece of 2-in. by 4-in. stock serves for the foot lever. A broach-like cutter about ⅛-in. in width fits into a die plate, as shown, with a rectangular slot for the cutting tool. The tool is mounted in a slot in the end of a holder made of cold-rolled steel and connected with a link to the foot lever.

The shear is mounted on a heavy bench, the die plate on the top, with a flanged guide under the top for the cutter holder. A small section is removed from the cutter guide flange for releasing the chips.

The cutter is ground to give a ⅛-in. chip, so that each stroke of the shear lengthens the slot by that amount. Longer cuts or chips up to an ⅛ in. have been made. However, the smaller chip is more rapidly made and with less effort on the part of the operator. A coil tension spring lifts the foot lever and cutter when the foot is released. This fixture is suitable for the small shop, can be made from easily available material and will find considerable usage where the shop handles occasional jobs requiring plate.

Washington, D. C. G. A. LUERS.



This foot-operated cutter, using a tool like a broach, is used to cut light plate and for doing other similar jobs.

Details of Construction and Some Possible Uses of a Growler

WE HAVE found our growler so useful for a variety of purposes that an account of how we use it may be of interest to other readers.

Our growler has an iron core 4 in. square in cross-section and is made in the shape of a horseshoe, as shown in *A* of the accompanying illustration. It is wound with 40 turns of two No. 7 B & S gage wires in parallel, although the two wires may be connected in series if desired. The growler is operated on a 220-volt, 60-cycle circuit.

In addition to its use for locating short-circuits and other defects in armatures and rotors, a growler can be used for a number of other purposes, such as locating shorts in stator, shunt and series field coils; as an autotransformer; as a testing transformer up to 2,000 volts or so; and as a step-down transformer for heating purposes or even for spot welding.

The use of a growler for testing armatures and rotors is well known and consists in placing it over the core, as shown in *B* of the illustration, passing current through coil *A* and moving a light piece of iron over all of the coils. If a shorted coil is encountered, the piece of iron will be attracted very noticeably.

In an armature of the average size, heat will be generated in the shorted coils, just as though the armature were in operation. A transformer action takes place when testing an armature with a growler. The armature completes the magnetic circuit; coil *A* acts as the primary of a transformer and the armature coils linked by the magnetic circuit act as the secondary. When a shorted coil is linked by this magnetic circuit the heavy secondary current set up in the coil creates a magnetic field around it; therefore, the piece of iron will be attracted when passed over the coil. It should be borne in mind that small, high-voltage armatures should not be tested in this manner without inserting a suitable resistance in series with the growler or lowering the voltage applied to the coil, as the induced voltage in armature coils with a large number of turns of fine wire may be excessive, especially in the case of certain types of armatures. In an armature wound for 500 volts a voltage high enough to puncture the insulation may easily be induced.

When testing a wound rotor the results are likely to be confusing if the rotor is connected in delta or more than one-circuit star. In such cases the circuits must be disconnected before testing; otherwise the rotor will appear to be shorted, due to currents flowing around through the closed circuits.

A growler may also be used for testing armature and stator coils before these are placd in the core. This test may be of considerable value where old coils are to be saved and used over again. In testing such coils a bridge made from laminated iron of the same cross-section as the growler core and placed across the gap, is necessary. An ammeter should be connected in series with coil *A*, the bridge placed across

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the gap, the switch closed and the ammeter reading noted. Then the bridge should be removed, a coil placed over one pole of the growler and a reading taken with the bridge in place. If the reading is the same as before the coil was put on, the coil is O. K. If the coil is shorted the ammeter reading will be much larger. Do not let the coil ends touch each other. It is possible to test a number of coils at once, but if a high ammeter reading is obtained it will be necessary to test the coils separately until the defective coil is located.

When testing shunt and series field coils in this way an excessive voltage may be induced, as mentioned before, if the proper precautions are not taken. A very low voltage may be applied to coil *A*, or perhaps a better way is to use a small bridge, one that is too small to carry all of the magnetic flux across the gap of the growler. It is advisable to make up several of these laminated iron bridges, ranging in size from 4 in. to 1 in. square in cross-section.

When testing used shunt field coils the induced voltage should not exceed 150 to 200 volts per coil In making these tests it is necessary to note the ammeter reading with and without the field coil in place, using the same bridge each time. If the coil is in good condition the ammeter readings should be the same. Series field coils may be tested in the same manner as shunt coils, except that the largest bridge should be used. If alternating current of high frequency is available it may be used to good advantage, at a higher voltage, as it will then be possible to increase the voltage per turn in the coil under test. This is helpful if an effort is made to locate short-circuits between the turns of the heavy conductor. This is also true when testing large, strap-wound armatures. If 220 volts are applied to coil *A* at a frequency of 60 cycles, and this coil has 40 turns, approximately 5.5 volts per turn will be induced in the coil under test. If 440 volts are available at 120 cycles, or 220 volts at the same frequency and coil *A* connected to have 20 turns instead of 40, about 11 volts per turn will be induced in the coil under test.

In using a growler as a testing transformer for giving ground tests and so on, it is necessary only to wind up a well-insulated coil with enough turns to produce the desired voltage. Taps may be brought out from the winding of this coil to give a wide range of voltages. When this coil is placed over one pole of the growler and a large bridge put across the gap, a step-up transformer results, with coil *A* acting as the primary and the other coil as the secondary.

In order to wind a secondary coil for any desired voltage, it is only necessary to remember the number of turns in the primary, coil *A*. For example, if it is desired to use 2,200 volts for testing and coil *A* has 40 turns, the secondary coil should have 400 turns, with 220 volts on the primary. A secondary coil for 2,200 volts should be wound in sections which should be well insulated from each other and then connected in series.

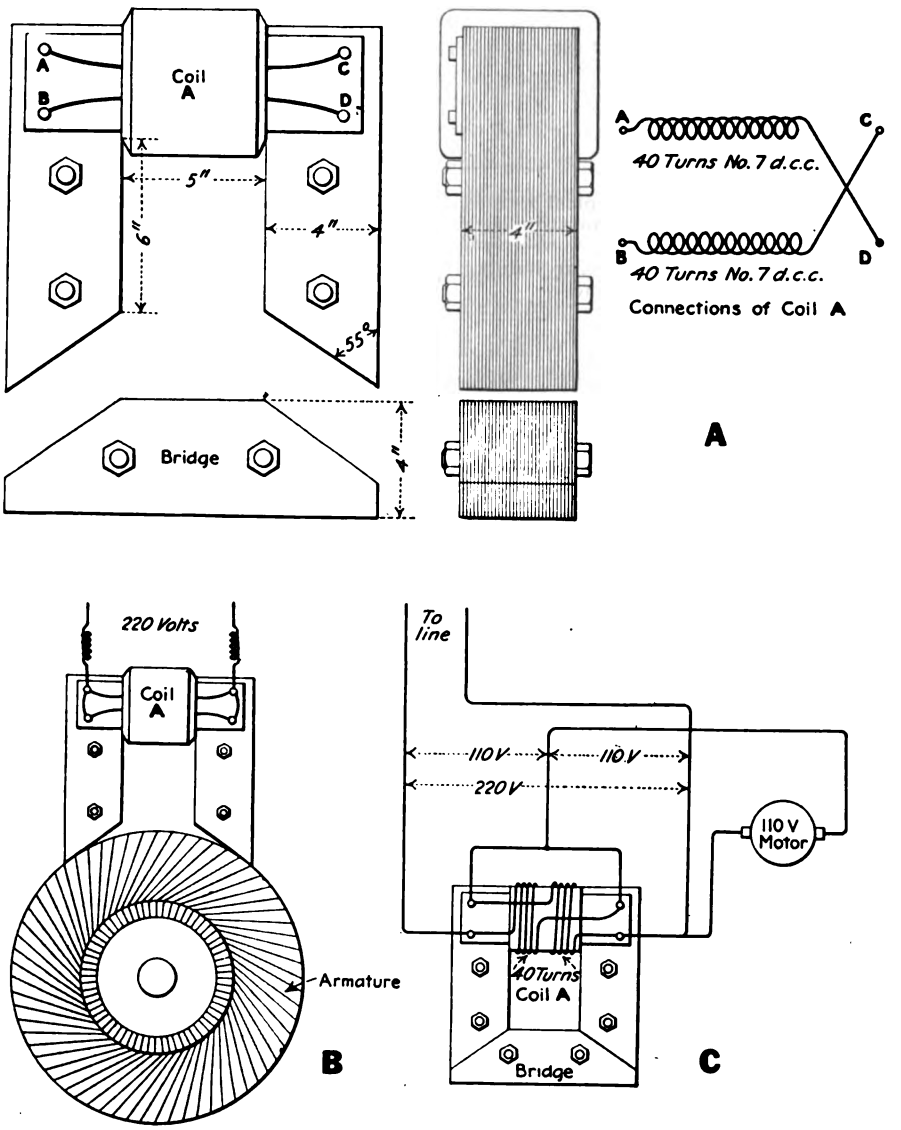
A growler can readily be used as an auto-transformer to obtain 110 volts from a 220-volt circuit, or 220 volts from a 440-volt circuit, and vice versa, if coil *A* is wound in two sections. When used as an auto-transformer it is, of course, good only for light loads. The connections are shown in *C* of the illustration. We have taken our growler out on jobs where only 220 volts were available and operated 110-volt drills from it for hours at a time.

A very few turns of rubber-covered cable may be placed around one pole of the growler, with the bridge in place, and a heavy current obtained at low voltage, if it is desired to heat a coil, a piece of wire or a section of winding. The ends of the rubber-covered cable are connected to the coil to be heated. If the voltage is not high enough for the circuit to which the secondary is connected, a few more turns of cable may be looped through the growler.

Even spot welding has been done, on a small scale, by looping a short piece of 250,000-circ. mil cable once or twice through the growler and connecting the ends to suitable electrodes.

Another instance where a growler was very useful occurred when we were rewinding a large motor which was changed from 440 volts to 2,200 volts. The slot space was limited; so it was difficult to provide for the additional insulation necessary for the higher voltage. After the coils were insulated and put in place trouble was experienced with a few of them, as they would not go down and allow room for the top wedge. The coils had been dipped in varnish and baked before taping. During the baking they had swelled more than was expected and it was not thought advisable to hammer them down. The growler was then made use of by placing about seven turns of No. 6 B & S gage wire around one pole; the ends of this wire were connected to one of the stator coils. When the current was turned on, the coil soon warmed up enough to soften the varnish so that the coil could easily be compressed into place and the wedge inserted. The other coils were treated in the same manner. When finished, the whole winding stood a ground test of 5,000 volts without trouble and was also tested with a smaller growler for

A, dimensions and details of core and winding of growler; B, method of locating defects in armature; C, connections for using growler as auto-transformer to drive small 110-volt motor from 220-volt circuit.



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short-circuits. This small growler was constructed in the same manner as the one described here, but was made to fit the inside of stator cores.

Still another instance where our growler did good work was on a locomotive armature which was brought in for commutator repairs. When soldering the commutator some solder accidentally ran down behind the bars and short-circuited two of them, too far down to be reached by any kind of tool, or without raising a large number of leads. We disconnected one upper lead from one of the shorted segments and raised an upper lead on the other side of the armature, in order to isolate the segment completely. Two turns of heavy, rubber-covered wire were looped through the growler and the ends connected to the shorted segments.

The armature was then turned over so that the solder could run out when it was melted. After the current had been on for about 15 sec. a small report was heard and the solder ran out. After this the commutator tested perfectly clear, and the leads were soldered down. This required only a few minutes on what otherwise would have been a long and careful job.

Shop Superintendent, W. E. PAULSEN.
Electrical Engineering & Const. Co.
Des Moines, Ia.

How to Repair Riveted-Type Commutators

A RIVETED-TYPE commutator, shown at *A* in the illustration, may be repaired without much difficulty, although it must be said that the labor cost usually does not warrant repairing them.

After the commutator is removed from the armature, it should be fitted into an adjustable clamp ring. A radiator hose clamp will serve this purpose, or one can be made as shown at *C* in the illustration. Put a piece of paper or fiber between the commutator and the clamp ring. This will permit of testing between bars while the commutator is in the ring.

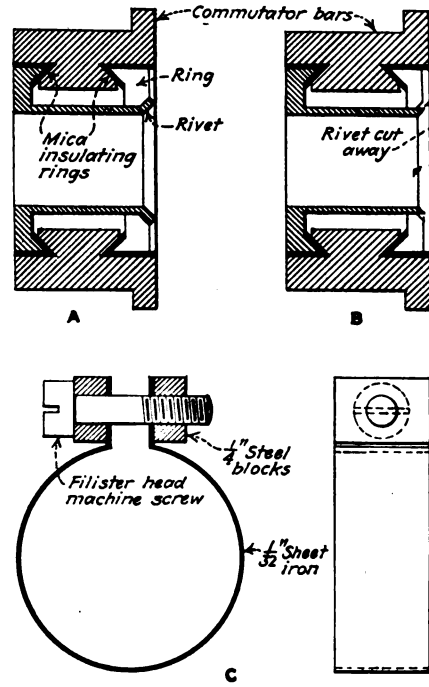
The ring and commutator should then be held in a lathe chuck and the rivet cut off. This should be done, as indicated in *B*, so as to leave enough metal to form a new rivet.

The core can now be removed, leaving the commutator in the clamp ring. The insulating rings should be removed and the inside of the commutator cleaned with sandpaper.

Test between bars for defective mica. If necessary to repair the mica segments the clamp ring may be loosened and the defective mica removed, still keeping the copper bars in their original position in the clamp. Be careful to replace the mica segments with others of the same shape and thickness; then tighten the clamp ring as much as possible. Test for short-circuits between bars. When free from shorts paint the inside bevels of the commutator with a thin coating of good quality shellac.

You are now ready to put in the mica insulating rings. The new rings must be the same thickness as the old ones. They should be made from molding mica-plate, which is a material made for this purpose.

It will be necessary to make templets for cutting the mica-plate to the proper shape. This is done by wrapping a piece of paper around the part of the core to be insulated, and marking the paper where it touches the end of the core. The paper is then unwrapped and cut to shape, which will be an arc of a circle. Try the templet to be



A, sectional view of typical riveted commutator; B, commutator with rivet cut off to allow core to be removed; C, ring clamp for holding commutator bars in place.

sure that it fits properly. With a saw cut the mica-plate the same shape as the templet, allowing for a lap where the ends meet. Heat the pieces of mica-plate to about 150 deg. F., or until they soften. While hot form them around the core and hold them in place until cold. The laps should be beveled so that the ring will be of a uniform thickness. Four rings will be required for each commutator, that is, two in each end.

The metal core is next put in place, the commutator riveted and the clamp removed. The commutator should now be baked for two hours at 300 deg. F. It should then be put back into the clamp ring and riveted again while hot. When cold it should be tested for electrical defects and if found O. K. is ready for use.

A tool for riveting the end of the core can be made from a piece of round steel, slightly larger in diameter than the part of the core to be riveted, by turning a 45-deg. bevel on one end. An old lathe center will answer, if available.

A tighter commutator can be made if a press is provided for pressing the parts of the core together before riveting, and for holding the core while it is being riveted.

Vice-Pres. and Treas., C. B. KECK.
The Homer Commutator Co.,
Cleveland, Ohio.

Using a 36-Bar Commutator in Place of One Having 24 Bars

THE commutator on a motor driving the blower of an oil-burning, heating furnace failed during a cold snap, and as there was very little direct-current apparatus in the community, the equipment company was caught without a spare armature.

The job was received in the shop with day and night service orders. Inspection showed that the windings on the armature and fields were both roasted out and that the commutator was damaged beyond repair. A good-sized hole was burned in the rear through the moulded Bakelite V-ring to ground. The copper bars of the commutator were also burned and pitted.

As the V-ring was of moulded construction, repairing was out of the question, and a search of the storeroom disclosed the fact that the nearest we could approach the commutator in size and fit was one having 36 bars.

In checking the armature winding we found that the armature had 12 slots and 24 bars, each slot containing two coils, that is, the slot held two top half-coils and two bottom half-coils. Each coil was wound with 12 turns of one No. 17 single-cotton and enamel-covered wire in band. A corded, split-loop winding having a coil pitch of 1-and-6 was used.

Now the question was, could the 36-bar commutator be used in place of the 24-bar commutator? Or would it be necessary to wait a week or more for a 24-bar commutator to be shipped from the manufacturer?

With 12 turns per coil and 24 single coils there was a total of $12 \times 24 = 288$ turns on the armature. This is equivalent to $2 \times 12 = 24$ turns per half a slot or 48 No. 17 wires in each slot. In using a 36-bar commutator we would have to have three coils per slot; that is, three top half-coils and three bottom half-coils, or 36 single coils. Then, since 288 divided by 36 equals 8, there will be 8 turns in each single coil. Also, since the number of coils per slot times the number of wires per coil equals 6×8, or 48, there will be 48 wires per slot, which is the same as was the case with the 24-coil winding.

The armature was accordingly rewound with eight turns of three No. 17 single-cotton and enamel-covered wires in hand, using a chorded split-loop winding having a pitch of 1-and-6.

The 8-turn winding saved time, as the original winding required 12 coils, each of which was wound with 12 turns of two wires in hand. In this case the winder had to make $12 \times 12 = 144$ turns In the new or 8-turn winding, although there were 12 coils, they were wound with three turns in hand, thereby giving fewer turns for the winder to make. With the new winding there were $12 \times 8 = 96$ turns which is 48 turns less than the 144 turns required by the old winding. This is equal to six 8-turn coils or four 12-turn coils less.

The 36-bar commutator also improved commutation as the voltage between bars was lower.

Wilkinsburg, Pa. A. C. ROE.

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Topics Discussed by Steel Mill Men

(*Continued from page 472*)

said that cross connectors are located at a point where they can be well insulated and easily gotten at. He also said that eddy current losses can be reduced in any type of winding by using split conductors and hence this feature could not be said to be an inherent advantage of the frog-leg winding. Split conductors are, in his opinion, unnecessary for the low speed machines used in the steel industry because the frequency of current alternation in these machines is not high enough to set up eddy currents of any great amount. He felt that it was desirable to design a machine with the smallest number of coils and bars that will commutate successfully. The frog-leg winding, he said, uses more coils than the regular type of winding.

He also thought it undesirable to change the speed regulation of a machine by shifting the brushes, for shifting them would slightly disturb the angle of the brush with the commutator, which would result in poor seating of the brushes. In reply to this point, Mr. Powell said that it was not the intention to secure continual adjustment of speed by this method—that the changes in speed should be made once for all upon the installation of the machine.

Mr. Page of the General Electric Co. said that consideration should be given to the fact that the frog-leg coil would require more bending and flexing of the ends in laying in the coils, thereby creating a tendency towards weakening the insulation.

George H. Schaeffer, Electrical Engineer, Carpenter Steel Co., said that he felt that the frog-leg winding was as big a step in advance as was obtained by the use of interpoles on direct-current machines.

In concluding the discussion, Mr. Powell emphasized the fact that improved commutation is obtained through the use of the frog-leg winding.

Selection and Maintenance of Oil Circuit Breakers—This was the subject of the two papers (abstracted on page 465) presented on the second day of the convention. In discussing these papers, Mr. Cummins pointed out that the investment required in circuit breakers is rapidly mounting and that careful consideration should be given to methods of reducing this initial cost. The question was raised as to the possibility of cutting this cost by reducing the current progressively through insertion of reactance in the line before opening the circuit. G. A. Burnham, general manager of the Condit Electrical Manufacturing Co., said that this has been tried abroad but, due to the extra expense of auxiliary equipment required, did not result in a reduction in first cost. His suggestion for reducing first cost is by the use of a master circuit breaker having sufficient interrupting capacity for the system and using low interrupting-capacity circuit breakers on the feeders. The latter are to be interlocked with the former so as to trip out only in case of sustained overload. On short circuits, the interlocked relays open the large breaker and keep the small ones closed. In his opinion, 75 per cent of the circuit interruptions will be found to be due to overloads which the small breakers will take care of. He pointed out, however, that a short circuit on one feeder with this arrangement will result in cutting off power from all feeders and this may be objectionable in some cases.

Mr. Burnham also said that great progress can be made in reducing the initial cost of circuit breakers by splitting up the arc by using more breaks in series, thereby securing more cooling for the same volume of oil. He thought this plan better than using some other medium than oil for quenching the arc as was suggested by some operators.

R. H. Keil, Power Engineer, Jones and Laughlin Steel Corp., said that in many cases the short time carrying capacity is the limiting feature in many circuit breaker applications and careful consideration should be given this factor before making an installation.

Electric Heating Applications—The discussion of the papers on this subject (abstracted on page 469) centered around the necessity of making an analysis of all of the factors involved when deciding whether to use electric heat or some other form of fuel such as gas, oil, and the like. Mr. Schaeffer said that comparisons based on the cost of heating only, are against the use of electricity; that comparisons must be based on the cost of the finished product. W. P. Chandler of the Carnegie Steel Co. pointed out that where a quality product is desired, electric heating should have preference. This is true in the case of heat treating of steel where a reduction in chipping cost can be attributed to the use of electricity for heating. Also the more accurate control that can be obtained with electric power reduces the human element which lowers the number of rejections. Aside from this, it was pointed out that there are some intangible considerations which are hard to capitalize and yet do cause electric heating to justify itself in many applications. These considerations are improved working conditions, such as the elimination of gas fumes, noise and the like. One operator stated his experience in this connection shows a decrease in labor turnover and an increase in production which can be attributed only to this factor.

In discussing Mr. Butler's paper on the electric soaking pit installation of the Donner Steel Co., T. F. Baily, president of the Electric Furnace Co., wished to emphasize the fact that the field of the electric soaking pit is in the heating of ingots that are charged hot. When cold ingots are charged, the gas fired pits are much more economical. Through the reduction of scale losses, the electric soaking pit can possibly be justified for heating cold alloy steel ingots. Mr. Baily said that when ingots are charged at an average temperature of 1,650 deg. F. and heated to an average of 2,250 deg. F., a fair figure for power consumption is 80 kw-hr. per gross ton of ingots charged. He also stated that a thermal efficiency of 50 per cent is actually being obtained with the experimental installation at Donner Steel.

Heating of ingot tops by an electric arc was described by F. C. Watson, Electrical Superintendent, International Nickel Co. He said that at his plant monel metal and nickel ingots were cast with the large end up. This meant that there was a large head to cut off and handle. By keeping the head of the ingot hot with the arc gives an ingot with a solid top, which does not have to be sawed off. He stated that after the ingot is poured a special top is put over the mold so as to keep the arc from spilling over on the sides of the mold. A 3-in. carbon electrode is inserted through a hole in this special top and run for 2 min. with a current of 2,000 to 3,000 amp., followed by a 3 min. run of 800 to 1,000

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amp. A standard type of furnace transformer is used for supplying the current at a potential of 90 to 100 volts.

At a business session it was announced that the 1926 convention would be held in Chicago and would take place during the first part of June instead of in September, as has been customary in the past.

The officers elected for the coming year are: president, George H. Schaeffer, Electrical Engineer, Carpenter Steel Co.; 1st vice-president, S. S. Wales, Electrical Engineer, Carnegie Steel Co.; 2nd vice-president, A. J. Standing, Superintendent, Electrical Department, Saucon Plant, Bethlehem Steel Co.; James Farrington and F. W. Cramer were reelected treasurer and secretary, respectively.

Determining Quality of Belts

(*Continued from page 484*)

probably would show in some one or more of the physical tests named.

Another requisite of a good belt is that it should be of the proper thickness. The former method of designating a similar requisite quality was by specifying the weight in ounces per square foot. For example, the former designation for medium single belts was 14 to 16 oz. per sq. ft. The present designation, as given by Paragraph 19 of the Specifications, shows that medium single belts in the narrower sizes, that is, from 1½ in. to 2 in. wide, should measure 10/64 in. thick, and in the wider sizes, from 4 to 6 in. wide, should measure 12/64 in. thick. Required thickness for light, medium, and heavy single-ply and double-ply belts is given in Paragraph 19 of the Specifications. Due to the difference in density of leather belts and the difference of grease content the system of designating the grade by the number of ounces per square foot has been unsatisfactory and the European practice of an actual measurement of thickness substituted.

Because of the fact that a strip of leather is of slightly different thickness at several points in its length, and to eliminate the necessity of taking a number of measurements at numerous points in its length, an average is secured by measuring the aggregate thickness of 15 or 20 plies of belt when it is in a roll and dividing this number by the number of plies measured. This average, although not absolutely uniform, will be sufficient for all practical purposes. Care should be taken also that the belts are accurate in width (Paragraphs 17 and 18) and a variation in width of more than 1 per cent on belts up to 24 in. wide is not permissible.

Substantiality is one of the qualities most desired in belts but a belt may be made of very excellent leather and still be inefficient as a transmitter of power, because the latter quality depends almost entirely on the treatment which has been given the grain or hair side of the leather. Many buyers think that if the belt feels firm and solid it must be leather of a high quality, and if it is finished highly with a brilliant gloss, it appeals to the eye as well finished material; but this is a mistake. The firmest and most solid leather is obtained by heavy rolling and jacking, and the highest polish by jacking, and both are destructive of the fibrous grain surface. The contact of the belt with the pulley is obtained by this elastic cushion of the natural grain, and when this is destroyed by mechanical action, the capacity for making a close pulley contact is much reduced; under test the rolled and jacked leather transmits little more than half as much power as that with a natural finish. Also it takes longer to wear in a belt with a high finish. The best belt makers, who have studied belts technically, take care to preserve the characteristics of the natural grain, so that their belts shall be not only durable, but shall be able to carry a full load on installation and a large overload after running a few hours.

It cannot be too strongly impressed upon the average industrial man, who, at best, has only a comparatively limited experience in the handling and judging of leather, that it is a grave mistake to attempt to judge leather solely by the appearance and feel. Manufacturers, who desire to, may treat and work up a low grade of leather until in appearance it may be more attractive than a high-grade belt which is not so highly finished; the durability and serviceability of the two belts, however, show up in operation. Moreover, the low-grade belt, no matter how highly worked and finished, will most likely be discovered by the simple tests for piping and cracking.

Features of a Good Lighting System

(*Continued from page 478*)

the reflectors, lamps and wiring, while little thought is given to how much the walls and ceilings contribute to the efficiency of the lighting system. Walls and ceilings painted a dark color, or darkened by dirt, reflect only a small portion of the light which strikes them. If the walls and ceilings are refinished with a matte white paint better utilization of light will result. Light-colored walls and ceilings increase the daylight, as well as artificial light, illumination.

Most industrial buildings are so constructed that columns or beams divide the rooms into bays. It is convenient to lay out the lighting system with respect to these bays, since they are usually of uniform size and once the location of the lighting units is determined in one bay or row of bays, the layout can be extended throughout the remainder of the room.

In some instances it may be necessary to design the lighting system in detail on account of irregularities in the building or for some similar reason. In general, however, good lighting can be obtained by mounting the units 10 ft. from the floor, spacing them 10 ft. apart, and equipping them with 200-watt Mazda lamps.

Local lighting for individual machines should be used only to supplement the general illumination in the room. There are many plants which are equipped only with a local lighting system. In such cases the illumination throughout the room is not uniform and the workers must accommodate their eyes to varying intensities of light, which results in undue strain upon the eyes, poor vision and lost time. A system of general lighting, such as shown in Fig. 1, will provide a cheerful, stimulating atmosphere in the workroom, with plenty of light to insure ease and speed of vision. If more light is needed at a particular machine than that which is supplied by the general lighting, a local lighting unit can be installed. However, in most plants where modern lighting systems have been installed, it has usually been found that local lighting is unnecessary.

There are some industrial plants where the location of lighting units

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is governed to some extent by the location of machines rather than by the structural features of the building. Paper mills, printing plants, textile mills and other industries in which large machines are employed, may require that the units be located with respect to the machines. This method of lighting is called "group" or "localized-general" lighting.

Power and Lighting Circuits Should Be Separate

The lighting system should not be supplied from motor and other power circuits. Variations in voltage or trouble in the power circuits will then not affect the lighting system. Exit lights should also be on separate circuits from the rest of the lighting system. A little thought on planning the arrangement of circuits so as to permit convenient and economical switching of lamps will be found profitable. For instance, if the rows of lamps parallel to windows are placed so that they can be turned on or off as daylight fails or becomes sufficient will aid in the economical use of light.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Pocket-Size Tester—A circular describes the AVO, which is a portable, pocket-size ammeter, voltmeter, and ohmmeter combined, for direct current testing. The same scale, may by the use of shunts and with simple adjustments of the instrument, be made to read in different values. For example, when used as an ammeter, either a 1-amp. or a 10-amp. scale range may be employed. This device may be used to measure voltages up to 250 volts, and also for battery testing on a 5-volt scale.—The Electrical Engineering Service, 15 Park Row, New York City.

Fire Alarm Siren—Bulletin 608 describes the Sterling Super Quad siren which has a double head and is driven by a 12-hp. motor. This siren may be operated by automatic or remote control. Other bulletins describe single- and double-head sirens of smaller size for signal and fire alarm service.—The Sterling Siren Fire Alarm Co., Inc., Rochester, N. Y.

Ball-Bearing Loose Pulleys—A booklet entitled "Shut Downs Are Costly" shows the Chicago line of ball-bearing loose pulleys, loose countershafts, friction clutches, the Daggett ball-bearing hanger box, and the Marvel ball-bearing emery grinder.—Chicago Pulley & Shafting Co., 23 N. Desplaines St., Chicago, Ill.

Repair Forge—A new forge designated as No. 236 with a one-piece steel hearth, 6 in. deep by 24 in. square is specially designed for use in general repair work.—Buffalo Forge Co., Buffalo, N. Y.

Wire Rope and Fittings—A bulletin entitled, "Two Basic Improvements in Wire Rope," describes the Tru-Lay rope, which is made by a special method of pre-forming each wire and strand before it is formed into rope. Eight advantages are given. This bulletin also shows the Tru-Loc steel fittings which consist of steel sleeves which fit over the smooth un-sleeved end of Tru-Lay rope. When placed in a press and subjected to pressure and hammering the fitting is made to "flow" down upon the rope until it grips the wires and strands. These fittings consist of turnbuckles, yokes, eyes and other fittings.—American Cable Company, Inc., 105 Hutchinson St., New York City.

Blueprinting Machinery and Accessories—Catalog M-23 describes and illustrates the various types and sizes of Pease Peerless blueprinting, washing, and drying equipment, together with lights and other accessories. Blueprint paper coating machines are also listed.—The C. F. Pease Co., 864 N. Franklin St., Chicago, Ill.

Anti-Friction Bearing Induction Motor—Circulars announce a new line of squirrel-cage and slip-ring induction motors equipped with Timken tapered roller bearings. These may be obtained in all ratings up to 200 hp. for 25 and 60 cycles.—Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Flexible Couplings—Catalog 26, containing 80 pages, illustrates the construction and operation of Thomas double- and single-engagement flexible couplings and gives dimensions and ratings. Numerous illustrations show applications of these couplings for mill drives, heavy pulsating service, mine hoists, pumps, motor and turbine drives, for three- and four-bearing, direct-connected drives, and other applications.—Thomas Flexible Coupling Co., Warren, Pa.

Threadless Conduit Fittings—A wall chart illustrates and gives dimensions and prices of the line of Kondu-Box threadless conduit fittings. A cross-section of a fitting together with arrows pointing out the advantages claimed for it, is also shown. Conduit without threads is connected to the box by a special tapered and slotted, case-hardened bushing with hardened rings on the inside which cut into the conduit as the bushing is tightened, thereby insuring solid ground connections. It is not necessary to cut threads on the conduits. These conduit fittings are non-breakable, as they are made of malleable iron.—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Paint Spray Brush—A circular describes the use of the Simons paint spray brush for paint spraying products as well as for painting ceilings, walls, columns, radiators and other building surfaces.—Simons Paint Spray Brush Co., Dayton, Ohio.

Electric Heating Units—Booklet C-100 describes the various Chromalox electric heating units, which are constructed in convenient forms for commercial and domestic heating, and gives ratings, dimensions and prices, as well as considerable electric heat engineering data.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Speed Reducers—Catalog 26 describes and illustrates the construction as well as a variety of uses of Foote Bros. IXL speed reducers which are made in spur and worm gear types. Considerable space is also devoted to the various types of couplings for connecting to the speed reducers. Dis-assembled reducers are illustrated and the various parts numbered and named so as to facilitate ordering of replacement parts. A large number of installations are also pictured and considerable engineering data given.—Foote Bros. Gear & Machine Co., 236-246 N. Curtis St., Chicago, Ill.

Distribution Transformers — Bulletin 2045, entitled "Pittsburgh Single-Phase and Polyphase Distribution Transformers" devotes 40 pages to a complete description and photographs of this equipment, together with diagrams showing test connections and a schedule of approximate dimensions of all sizes and voltages of distribution transformers rating from 1½ kva. to 200 kva., 440 volts to 4,400 volts, single-phase and polyphase.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Electrical Industrial Trucks and Tractors—A 40-page catalog describes the several different types of electric storage battery industrial trucks and tractors, gives specifications, illustrates and describes the various construction features and shows a number of industrial applications.—The Crescent Truck Co., Lebanon, Pa.

Heavy Soldering Iron—Literature announces two new types of soldering irons which are designed for use on heavy work. These are made in two styles: with a spear shape and a hatchet type of tip. The complete iron weighs 5½ lb. and the tip is 3 in. long by 1¼ in. wide on its working surface; it consumes 500 watts at 110 volts.—Harold E. Trent, 259-261 N. Lawrence St., Philadelphia, Pa.

Ball Bearings—Catalog 26, entitled "Industrial and Textile Applications," deals with the application of Fafnir ball-bearing transmission equipment to shafting, blowers and textile machinery of all types. Illustrations of actual installations and complete and up-to-date data on the principles of ball-bearing equipment make this a handbook as well as a catalog. Some of the units listed are double and single bearing boxes of several types, countershaft boxes, loose pulleys and

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blower boxes. Miscellaneous other applications of this line, which covers a complete range of ball-bearing transmission equipment are also illustrated.—The Fafnir Bearing Co., New Britain, Conn.

Transformers—Bulletin 230 gives a brief history of the transformer, discusses some of the fundamental principles involved in its design and operation and gives rules for its operation.—Moloney Electric Co., St. Louis, Mo.

Leather Belts—A series of booklets discuss applications of "Pre-Tested Leather Belts" in six different industries. These booklets go into detail as to the special types of belt used in each of the following industries: machine shops, cement plants, saw mills, steel mills, paper and pulp mills, and the mining industry, including quarries and brick plants. When requesting copies, please mention the industry in which you are interested.—Chicago Belting Co., 113 N. Green St., Chicago, Ill.

Speed Reducers—A 12-page catalog describes and illustrates the operation of the Lipe planetary speed reducer, which is totally enclosed and provided with ball bearings at both the high- and low-speed ends. The Lipe flexible coupling is built into the low-speed end of this speed reducer. This reducer can be furnished in any ratio from 4 to 1, to 25 to 1 in single reduction and up to 200 to 1 in double or triple reduction, and in any horsepower up to and including 500 hp.—W. C. Lipe, Inc., 208 S. Geddes St., Syracuse, N. Y.

Pneumatic Conveying—A number of bulletins describe various installations of Dracco pneumatic conveying systems which are used for conveying bulk, pulverized and semi-pulverized materials of various kinds, such as rock phosphates, rice and rice meal, fertilizer, lithophone, arsenic in smelting plants, white clay, and so on. These systems can be used for unloading, storage and rehandling.—The Dust Recovering & Conveying Co., Cleveland, O.

Soldering Transformer—Circulars discuss the King soldering transformer, Style S, which consists of a small transformer for attaching to 110- or 220-volt, 60-cycle current supply. This transformer supplies three degrees of heat—low, medium and high. One electrode is a carbon rod while the solder or other material forms the other electrode.—The Electric Heat Control Co., 6536 Carnegie Ave., Cleveland, Ohio.

Motor Maintenance Equipment—Catalog 6 covers a line of commutator slotting and grinding equipment as well as other motor maintenance specialties, such as commutator cement, insulating varnish and "Blower Clean" which is a portable cleaner used as either a blower or vacuum cleaner.—The Martindale Electric Co., 11709 Detroit Ave., Cleveland, Ohio.

Electric Grinders, Buffers and Polishers—Catalog 315 covers the line of C. A. W. grinding and buffing equipment and shows the construction with several sectional views. This equipment is made for medium and heavy-duty service in both bench and pedestal type. Timken tapered roller bearings are used on all motors over ¼ hp. rating.—Cleveland Armature Works, Inc., 4732 St. Clair Ave., Cleveland, Ohio.

Condulets for Stock Bin Installations—Folder 22 and Bulletin 2070 describe this special condulet and show some of the usual arrangements around stock bins and the use of attachments which take up a minimum amount of space and offer but little obstruction in the aisle.—Crouse-Hinds Co., Syracuse, N. Y.

Ball Bearings for Motors—A booklet entitled, "You Can Lower the Maintenance Expense of Your Electric Motor," gives figures showing the comparative maintenance cost of ball-bearing and non-ball-bearing motors based on an actual installation.—The New Departure Mfg. Co., Bristol, Conn.

Oil Circuit Breakers—Bulletin 67445 B Class 2, shows the Types FK-35 and FK-35-Y oil circuit breakers of 600 and 7,500 volts capacity for use on alternating-current circuits where breakers of moderate interrupting capacity are required. Circular 67456 A-2 covers the type SKO-37 oil circuit breaker of 15,000-volt capacity.—General Electric Co., Schenectady, N. Y.

Unit Air Filter—Bulletin F-370 describes briefly the Type U 2 new model Midwest unit air filter for providing clean air, and shows its operation. Bulletin F-342 shows briefly other types of Midwest air filters used especially in connection with compressors and internal combustion engines.—Midwest Air Filters, Inc., 100 East 45th St., New York City.

Polyphase Transformers—Bulletin 2041 is devoted to a discussion of comparisons between the use of three-phase transformers and three single-phase transformers. — Pittsburgh Transformer Co., Pittsburgh, Pa.

Portable Elevators—Bulletin 76 covers a new line of combination hand-motor portable elevators that are made to be operated by either hand or motor according to whether power is or is not available. These are made in regular capacities of 500, 800, 1,000, 1,500, 1,800 lb. and can be furnished up to 2,000 lb.—Revolvator Company, 336-353 Garfield Ave., Jersey City, N. J.

Lifting Magnets—Bulletin 107 describes Ohio lifting magnets and discusses and illustrates their use in the iron and steel industry as well as for the magnetic separation of tramp iron from ore, cement, coal and other materials over conveyors or chutes. Numerous illustrations show profitable applications for handling pipe in warehouses, rails and iron or steel scrap in bulk.—The Ohio Electric & Controller Co., 5900 Maurice Ave., Cleveland, Ohio.

Hole Cutter—A circular entitled, "The Hole Story" describes the use of the Jiffy adjustable cutter which is used to cut holes from ¾ to 6 in. in diameter in any gage of metal up to ¾ in. in thickness. This cutter is made in either hand or drill-press types.—Paul W. Koch & Co., 23 So. Wells St., Chicago, Ill.

Unit Heaters—Folders describe the "Breezo-Fin Heaters" which consist of a unit heater filled with copper tubes with fins for coils and enclosed in a galvanized iron housing. Air is blown through these steam-heated coils by a Buffalo Breezo Fan.—Buffalo Forge Co., Buffalo, N. Y.

Industrial Tramrails—Bulletin TR-506 entitled, "Cut the Inside Freight Bill at Your Plant," shows a large number of illustrations of installations of Cleveland electric tramrails in a wide variety of industries, and demonstrates how they are used for reducing the cost of labor and material handling.—Cleveland Electric Tramrails, Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Non-Metallic Gears—A folder entitled "Cy-lent Gears and Motor Pinions" describes the use of this non-metallic gear in industry. This includes the advantages claimed, some of the applications and also a price list of the various sizes, up to 12 in. outside diameter and 10¾ in. wide.—Timing Gears Corp., 2801-15 Fulton St., Chicago, Ill.

Lamp Maintenance Equipment—Catalog 25, bearing the above title, describes the Thompson safety lowering switch or disconnecting hanger which enables high lamps to be lowered away from the electric circuit for cleaning and renewing. This catalog not only shows a variety of applications of this lowering switch but also gives details of construction and various methods of installing lamps of different types.—The Thompson Electric Company, 226 St. Clair Ave., N. E., Cleveland, Ohio.

Transformer Oil Purifier — Leaflet L 20240 describes the "Sharples Super-Centrifuge Oil Purifier" and gives the applications, distinctive features, operation and construction of this equipment for the treatment of oil used in transformers, oil switches and for other insulating purposes. This purifier is made in either stationary or portable outfits. The larger machines have a capacity of 500 to 600 gal. per hr. and, it is stated, will purify oil until it will test 22,000 volts or better.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Flexible Fixture Hangers—Bulletin 2063, bearing the above title, shows a line of condulet fixture joints and fixture hangers which permit of a slight swing of the fixtures due to a draft or other causes which might break the conduit line if it were rigid, and also permit the fixtures to hang plumb even though the conduit may be inclined.—Crouse-Hinds Co., Syracuse, N. Y.

Electrical Protecting Materials and Conduit Fittings—Catalog 30 devotes 96 pages to the listing, description and prices of the various types of fuses, panel and switchboard fittings, special fuses, switch boxes and various outlet boxes, as well as other material manufactured by this company.—Chicago Fuse Mfg. Co., Laflin and 15th Sts., Chicago, Ill.

Automatic Switching Equipment—Circular 67716-A, Class 17, describes automatic switching equipment for indoor alternating-current reclosing feeder service from 440 to 7,500 volts. This description includes the advantages, standard equipment, operating range, optional equipment, motor mechanism, reclosing relay, and operation.—General Electric Co., Schenectady, N. Y.

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

November, 1925

McGraw-Hill Co., Inc. Chicago, Ill.

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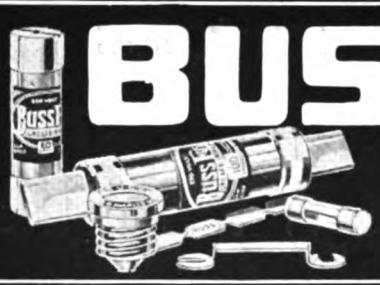
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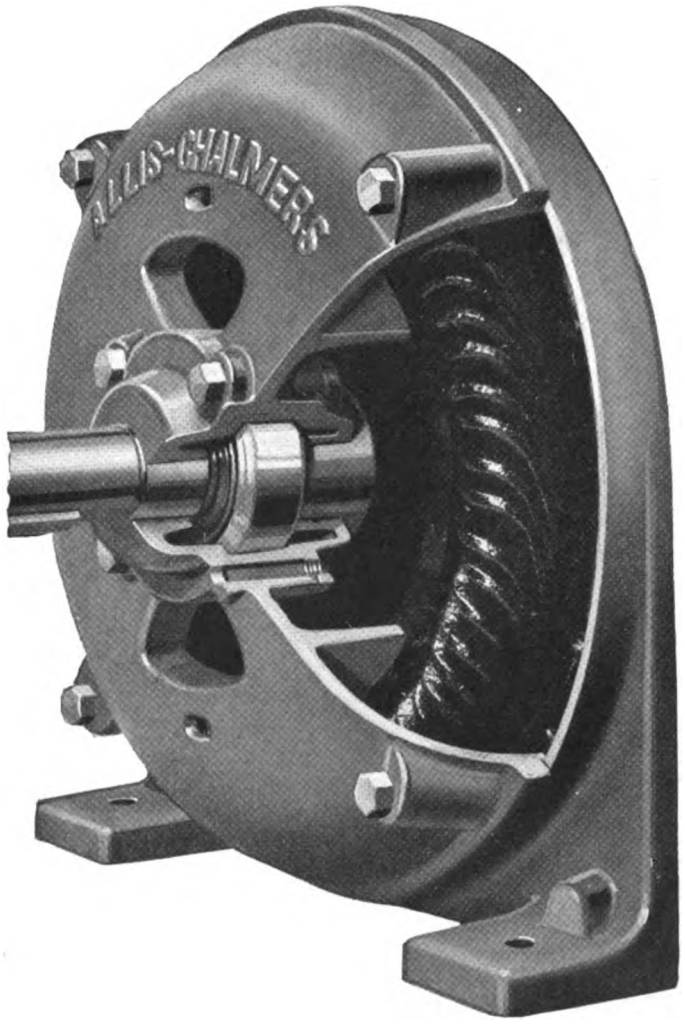
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Volume 83

INDUSTRIAL ENGINEER

Number 11

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

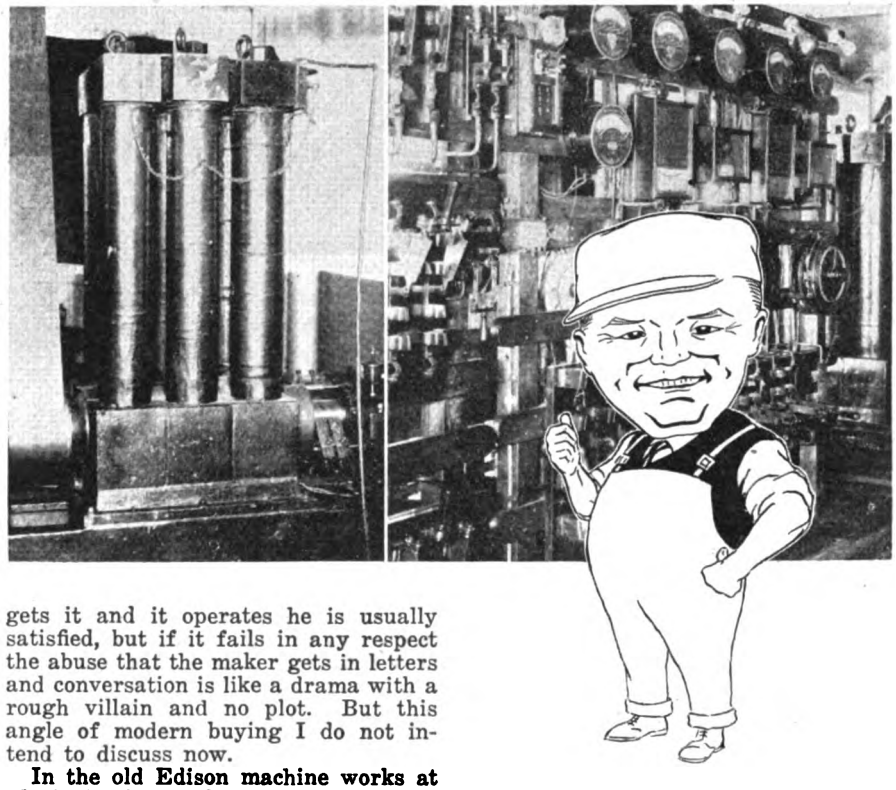
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Chicago, November, 1925

G. A. VAN BRUNT, *Managing Editor*

Here's an Old Timer Installed 43 Years Ago

with its old switchboard dressed up with some later-day instruments



HERE is a generator that takes you back to the beginnings of generator design in Thomas A. Edison's machine shop at Menlo Park, N. J., in the late '70's. This particular machine and three others like it are still in operation in the plant of the Grinnell Manufacturing Corporation at New Bedford, Mass., where they were installed in 1882, about 43 years ago. Certainly the designers built better than they knew, for these machines have worn themselves out twice over, according to the modern rule of applying depreciation on an estimated useful life of 20 years. But still they carry the lighting load and appear to be able to do so for some time to come.

From the standpoint of maintenance it is interesting to know that each machine during the past 43 years has had one new commutator and with the exception of repairing one or two bearings and renewing the brushes, no other repairs have been found necessary.

As will be noted, they are driven by almost vertical belting from a line-shaft, an arrangement that would not be recommended today for so-called mechanical reasons, but this drive and these generators have not and do not perform according to opinions or modern engineering ideas; they just keep on going as good machines might be expected to operate, with no need for excuses or apologies of any nature on the part of the designer or the operator. It would be a happy day in many a plant if some modern equipment would perform in like manner. But in the old days when these generators were built the idea was to produce the best generator possible, contrasted with the idea often found today of building the best design that can be made cheap and stand a show when the buyer sharpens his pencil and sets out to see just how little he needs to pay to get the thing, on which he has asked all the Toms, Dicks and Harrys in the manufacturing business to bid, delivered in his plant. When he gets it and it operates he is usually satisfied, but if it fails in any respect the abuse that the maker gets in letters and conversation is like a drama with a rough villain and no plot. But this angle of modern buying I do not intend to discuss now.

In the old Edison machine works at Menlo Park the first generators built in 1880 were called "Z" dynamos. In re-designing these "Z" machines a few years later they were enlarged by adding an extra field magnet and lengthening the armature and the base. These redesigned machines were called "L" dynamos. The "K" design came along about the same time, and is the design shown in the accompanying illustration, still larger than the others, with three field magnets all of the same size as in the "Z" machine, but with a longer armature and base. These machines embody Mr. Edison's original conception of a dynamo with an armature of very low resistance as compared with the total resistance of the machine.

The old switchboard, also shown in the illustration above, was installed at the same time as the generators. On it can be seen an old-type field rheostat which was used for all three generators. Much difficulty was experienced in getting the three machines to operate in parallel, and to do this the brushes had to be continually adjusted. But this is no fault peculiar to these machines; no doubt there are many who read this that can tell some interesting tales about getting some modern machines to divide their loads equally.

Some of you men may wonder why I have dug up this old stuff to talk about, and to you I will simply say this: If you will visit one of these old installations and get a good understanding of the abuse these old machines have stood, you will have more respect for good design in machines, and when you are called upon to buy equipment in the future you will not compare equivalent machines on the basis of dollars per pound. Design ability and successful operation are not rated that way. To those of you who have had years of experience with some of the good designs that have been and still are made, I have nothing to say. You know the whole story and could probably write a good article some day around your experiences. By the way, this would be well worth your while and INDUSTRIAL ENGINEER would be interested in publishing it if you make it good and full of details. In case you happen to have an old-timer in your plant, just drop me a line and I'll help you to frame up an article that will be so good that the Editors will be glad to print it.

Practical Pete

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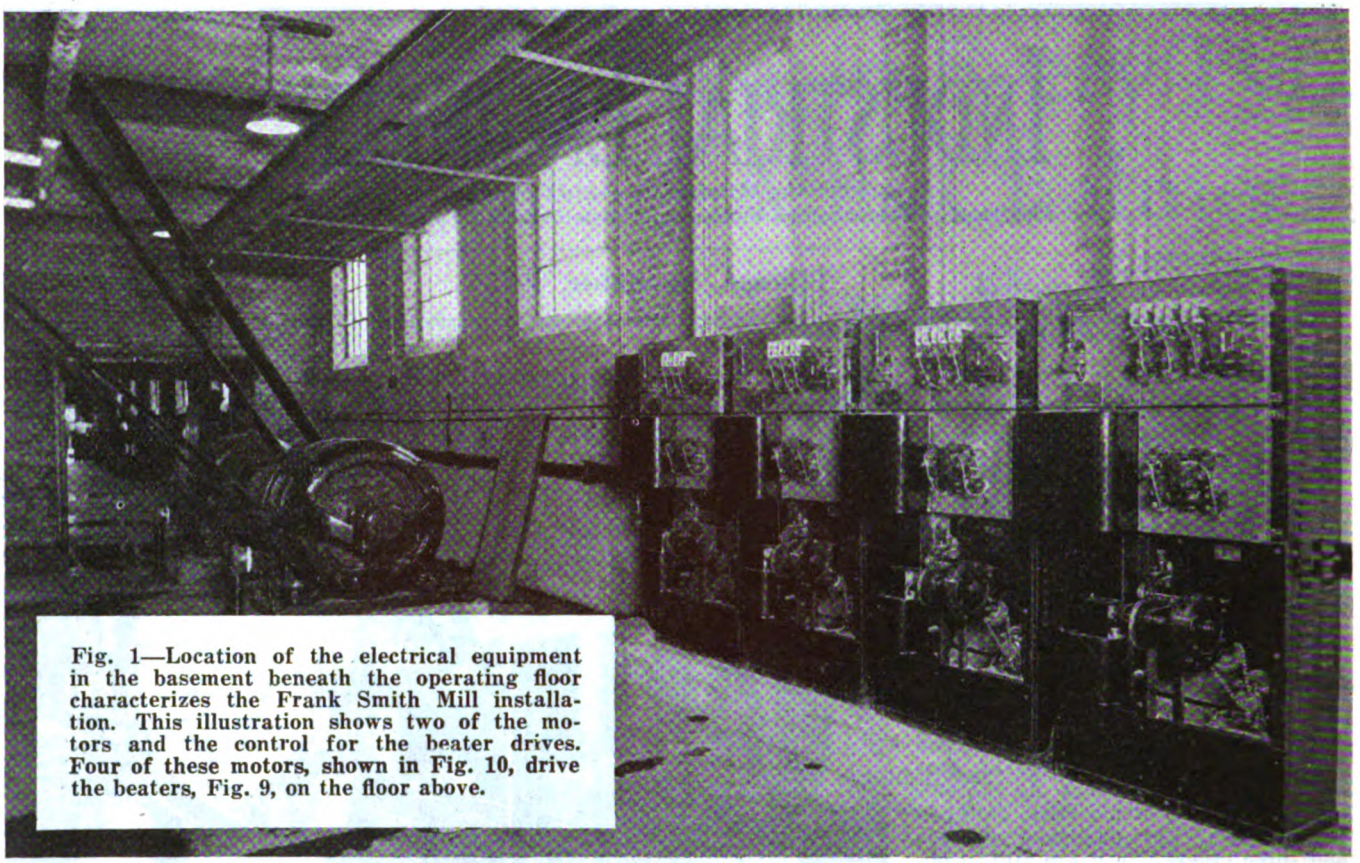


Fig. 1—Location of the electrical equipment in the basement beneath the operating floor characterizes the Frank Smith Mill installation. This illustration shows two of the motors and the control for the beater drives. Four of these motors, shown in Fig. 10, drive the beaters, Fig. 9, on the floor above.

Some new ideas about

Paper Mill Power Drive and Motor Control Layout

that were applied in a new mill to the installation of power service equipment, including the types of motors, methods of control, and kinds of drives used

By C. S. NEWCOMB

Chief Electrician, Paul A. Sorg Paper Co., Middletown, Ohio.

SOME novel and interesting features of design and layout have been embodied in the distribution, application, and control of power service in the new Frank Smith mill of the Paul A. Sorg Paper Co., at Middletown, Ohio. Naturally, continuous service with few delays was uppermost in the minds of the men laying out the drive applications. However, there were four other thoughts behind the installation. They are: (1) Remote-controlled, automatic operation throughout, thereby permitting the use of cheaper, unskilled labor as well as giving greater protection to the equipment involved. (2) Location of electrical equipment so as to give the greatest measure of protection from corrosive elements common to paper mills. (3) Convenience of making changes, re-arrangements, and expansions. (4) Ease of maintenance and repair. These factors lay behind the selection and installation not only of the electrical equipment, but also of the mechanical elements such as belts, gears, couplings, clutches and the like, which are also a very decided factor in the success or failure of a drive application.

The Frank Smith mill was built with the idea of producing paper specialties; all grades of paper are intended to be produced, from tissue to high-grade bond paper. This mill does not produce paper pulp. The process starts with shredding of the raw material, which is then put through the bleaching process, through the beaters and Jordan engines and into the machine room, where it is converted into the finished product.

The front portion of the mill building is known as the bleach house, the middle portion as the beater room and the rear as the machine room. A basement extends under the entire building and the bleach house and beater room consist of more than one floor, although practically all of the paper making equipment is either on the ground floor or in the basement.

To protect the electrical equipment from the water and corrosive elements common to paper mills, as many of the larger motors as possible were located in the basement. Out of a total of 66 motors it was found possible to place 36 of them in the basement. The basement is clean and dry and gives plenty of room around the motors for inspection, maintenance and repair. Also, this arrangement gives more free space around the equipment on the floor above.

Automatic or push-button control is used throughout, which permitted the location of the control panels at any place desired. However, the panels are grouped in three locations in the basement: one group consists of the controllers for the bleach house (shown in Figs. 5

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and 6); the second group is for the beater motors (shown in Fig. 1), and the third group consists of the machine room controllers, a portion of which are shown in Fig. 11.

Centralizing the controllers and placing the majority of the motors in the basement or on the floor above greatly simplified the distribution system. The average load taken by this mill is approximately 1,500 kw. A large share of this load is supplied from the local public utility, the balance being taken by the power house in one of the nearby mills of the company. Power is brought in at 13,200 volts and stepped down by transformers to 440 volts, at which voltage it is distributed throughout the mill. There is also a small amount of 230-volt, d.c., power used. Feeders go from a seven-panel switchboard located in a corner of the rear end of the main floor, through the floor to a conduit system that is carried on the ceiling of the basement. This system is carried along the ceiling so as to reach the three groups of control panels. Connecting conduit was easily dropped to each group of control panels; likewise, conduit was readily carried down the wall or the building columns to motors in the basement. The motors on the floor above were easily reached by conduit through the floor. This arrangement of conduit and controllers used a minimum amount of conduit, did away with the need of distribution boxes, and kept the conduit accessible so that alterations or repairs could be easily made.

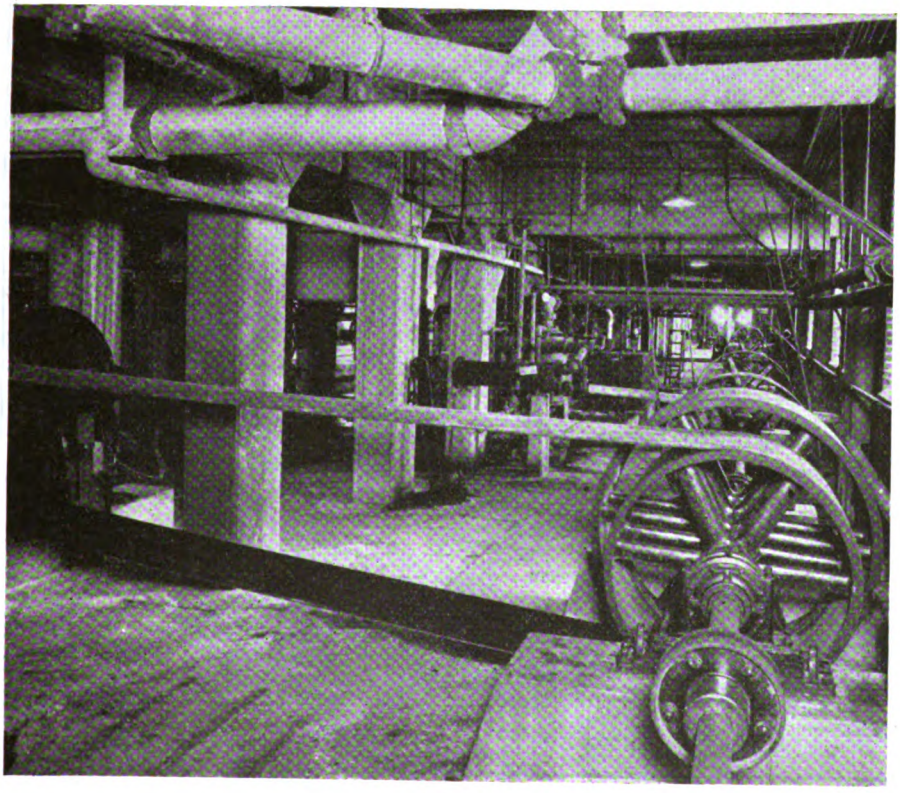
Centralizing the controllers in this manner would result in a large number of conduits coming together over each group of controllers and due to crossovers and interconnections, the result would be an awkward installation. To eliminate this, pull boxes were installed over each group of control panels and also at such other points where it would otherwise be necessary to group a large number of conduits.

The pull boxes were made of sheet iron fastened to angle-iron frames, as shown in Fig. 11. The boxes are hung from the ceiling. Sections of one side of the boxes are hinged at the top as shown in Fig. 11, thereby permitting inspection. Crosswise racks are placed in the boxes so as to permit carrying the wires in three layers, two layers being supported by racks while the third layer lies on the bottom of the box.

One disadvantage of this system of distribution lay in the fact that it would be hard to locate the wires for a given motor and control unless some system of identification were used. This was overcome by the use of identification tags and colored wire. Tags were placed on the wires at the motor terminals, control panel terminals and also in the junction and pull boxes. Each motor was assigned a series of two or three letters; for instance SA represents No. 1 Bleacher motor in the bleach house. An additional letter is added to distinguish which circuit of this motor is involved, as P for primary or line, S for secondary, and C for control. In addition the phases are numbered 1, 2 and 3. Hence, a wire with a tag number SAP 2 indicates that it is the wire for the second phase of the line or primary side of the motor. The control wires that run from the push buttons to the panels are colored, the start wire being green, the stop wire red, and the common return wire black. Other colors are used for the meter wiring. In addition to this, a diagram was made showing the location of the conduit and the pull and junction boxes. This diagram also shows sections taken at the ends of the boxes where conduits enter and the wires in each conduit at the points where these sections are taken are marked with the same information as is put on the tags.

Fig. 2—A lineshaft running in ball-bearing pillow boxes is used on the variable-speed paper machine drive.

The seven sections of the paper machine are driven by the variable-speed, shunt-wound, Crocker-Wheeler motor shown at the left. The lineshaft runs in ball-bearing pillow boxes mounted on concrete pedestals. The control for this motor is shown in Fig. 11.



In the bleach house there are 23 motors ranging in size from 1½ hp. to 100 hp. A list of these motors, together with the equipment driven, is shown in Table I. As can be seen from the list the drives required are for pumps, fans, agitators, filters and the like. All of the machines have individual drive because simultaneous operation of all of them is not essential for continuous production. Direct drive through flexible couplings is used for the higher speed applications while belt drive is used for those of slower speed. In case of very slow speed drives, a back-geared motor is belted to the machine, as shown in Figs. 4 and 7.

As was stated earlier in the article, the control panels for the motors in the bleach house are grouped together at one point. Front and rear views of this control board are shown in Figs. 5 and 6. Allen-Bradley automatic primary-resistance type controllers, across-the-line type starters, and secondary-resistance type starters for wound-rotor motors are used. Overload protection is obtained through circuit breakers or overload relays on each panel. The resistors are of

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the compression type made by the Allen-Bradley Co. Since these resistors are in the form of long tubes they could be mounted directly behind the panels without preventing access to the wiring on the rear of the panels, as is shown in Fig. 6. This gave a very compact arrangement. The illustration also shows the terminal boards at the top and center of the panels.

The eight beaters in the beater room are driven by five motors located in the basement. Ordinarily four beaters are required for normal operation; so four beaters are belted to one lineshaft which is also located on the floor of the basement beneath the beater floor. The remaining four beaters have individual drives and are used to take care of the peaks in production and also act as spare equipment in case any of those in the group drive have to be shut down.

Because of the high starting torque required, wound-rotor motors are used for the individually-driven beaters. These are Crocker-Wheeler motors rated at 85 hp., 385 r.p.m., and are belted to the beaters. These motors are shown in Figs. 9 and 10.

From Fig. 9 it will be seen that the beaters are arranged four in a line. The group shown contains the ones that are individually driven. Immediately to the left is a second row of four beaters, which are driven from a lineshaft. This lineshaft is



Fig. 3—Push-button control stations are located at convenient points adjacent to the machines controlled.

Here are shown the push buttons for starting and stopping the synchronous motors driving the Jordan engines; also, the stop button for the constant-speed drive. The meters inside the cabinets are calibrated in horsepower and indicate the load on the motor which the push button controls.

placed on the floor of the basement directly below the driving pulleys of this group of beaters. The lineshaft is coupled directly to an Electric Machinery Co.'s synchronous motor rated at 265 hp., 450 r.p.m., as is shown in Fig. 12. The use of the synchronous motor for this application counterbalances the comparatively poorer power factor of the wound-rotor motors driving the other beaters. Also it aids in improving the power factor of the entire plant.

The lineshaft is located in the basement and is directly under the driven pulleys of the beaters. It is supported on sleeve-bearing pillow blocks which are mounted on concrete pedestals. A belt wrapping and tightening device known as the Lenix Drive (made by F. L. Smidth & Co.) is used on each lineshaft pulley. This not only provides a means of independently disconnecting each beater in the group, but also permits operation with a short distance between centers of driving and driven pulleys. In addition, the Lenix Drive insures that sufficient area of the driving pulley is in contact with the belt going to the much larger driven pulley on the beater directly overhead.

Table I—Drive Data of the Equipment Used in Bleach House

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
No. 2 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
No. 3 Bleacher	Wound rotor	50	860	Allis-Chalmers	Automatic	Allen-Bradley	Belt
Shredder	Wound rotor	100	1,165	Allis-Chalmers	Automatic	Allen-Bradley	Flex. coupling
Vacuum pump	Squir. cage	40	860	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Plunger stuff pump	Squir. cage	7.5	570	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Filter pump	Squir. cage	30	1,155	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Bleached stock pump	Squir. cage	20	860	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Filter overflow pump	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Flex. coupling
Filter drive	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Reduction gear
Washer water pump	Squir. cage	20	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator bleach chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Agitator filter chest	Squir. cage	15	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Gear and belt
Vacuum pump	Squir. cage	10	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Back gear
Alum tank agitator	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Gear and belt
Air compressor	Squir. cage	1.5	1,750	Robbins & Myers	Across-the-line	Allen-Bradley	Belt
Shredder conveyor	Squir. cage	3	1,140	Allis-Chalmers		Allen-Bradley	Gear and belt
Shredder blower	Squir. cage	30	685	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Two elevators	Squir. cage			Warner Elev. Co.			Direct
Heater	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt

Table II—Drive Data of the Equipment Used in Beater Room and Pump House

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 2 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 3 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
No. 4 Beater	Wound rotor	85	385	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Nos. 5 to 8 Beaters	Synchronous	265	450	Elec. Machine Co.	Automatic	Elec. Mach. Co.	Direct
Heater	Squir. cage	2	1,135	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
No. 1 Deep well pump	Squir. cage	40	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Direct
No. 2 Deep well pump	Squir. cage	40	1,150	Allis-Chalmers	Man. compensator	Allis-Chalmers	Direct
Heater	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt

All motors are for 440-volt, three-phase service.

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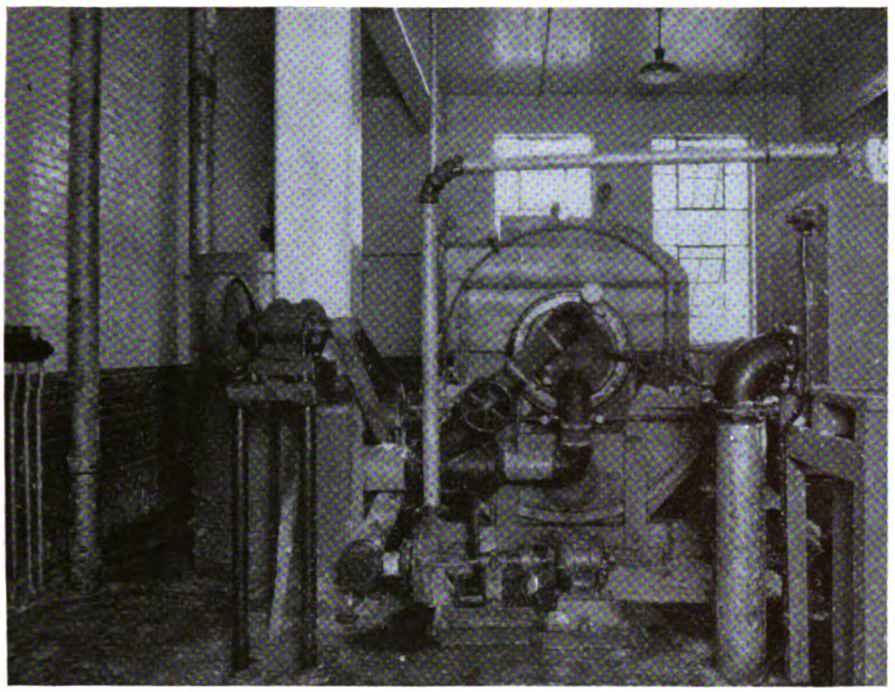


Fig. 4—Drive installations used in the bleach house.

The back-geared motor at the left drives the shredder chest through a belt. In the center is a small pump directly connected to a motor through a flexible coupling. The push buttons for these two motors, as well as a third motor, are shown at the extreme left. The control panels for these motors are in the basement and are part of the group shown in Fig. 10.

When starting the synchronous motor, the counterweights on the Lenix Drives are raised, thereby permitting the belts to hang slack and causing the motor to start the lineshaft under no-load conditions. Electrical interlocks, controlled by the position of the counterweights on each Lenix Drive, are connected in series with the start button of the motor control so as to prevent starting the synchronous motor in case any of the Lenix Drive units have not been released.

Belts are used on all of the beater room drives as these provide a very economical method of connecting the driving pulleys of the lineshaft and motors with the driven pulleys on on the beaters on the floor above.

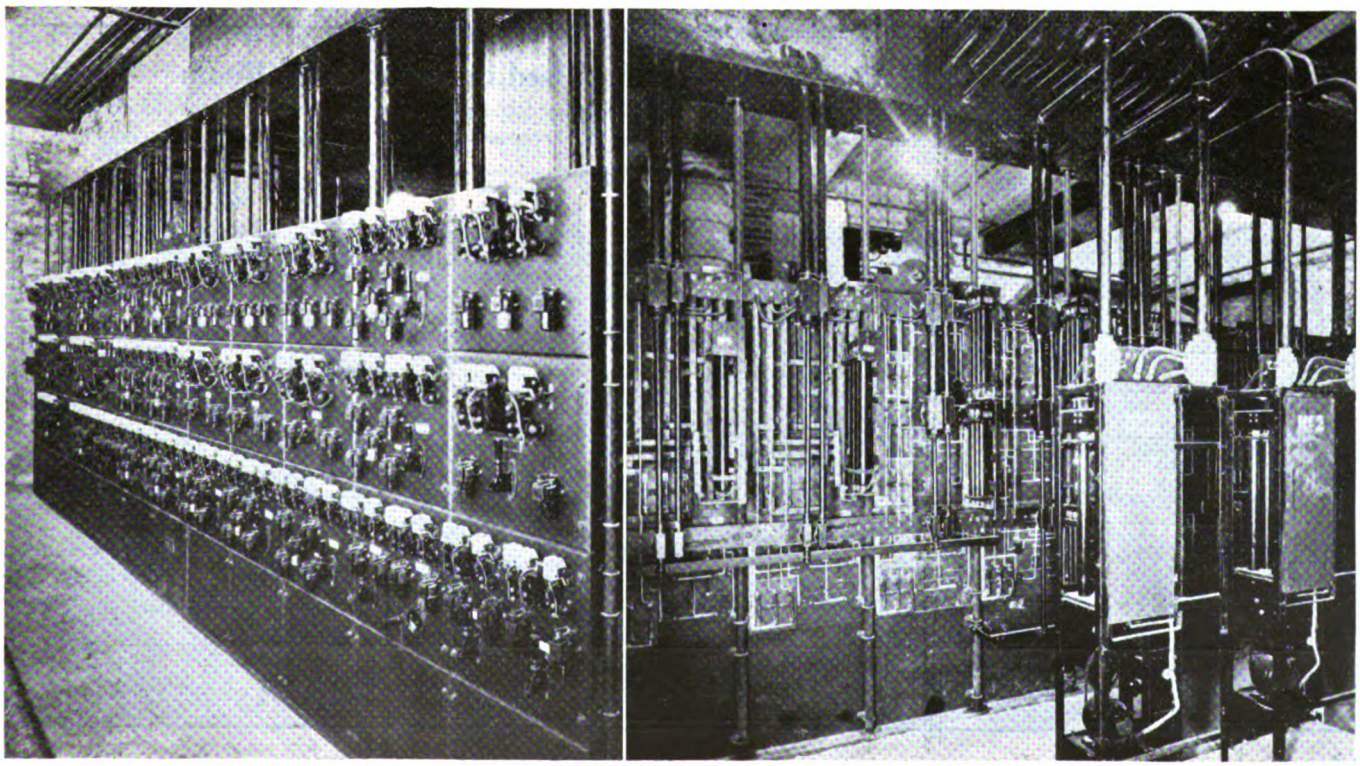
Figs. 5 and 6—Grouping of individual control panels at central locations is a feature of the control installation.

This control board is made up of Allen-Bradley across-the-line starters and automatic, primary-resistance starters. Fig. 6, right, shows the neat arrangement of resistors made possible through the use of compression-type tube resistors. The two controllers in the right foreground are current- and time-limit secondary resistance starters for the bleacher slip-ring motors.

The control for the synchronous motor is an Electric Machinery Co.'s push - button - operated automatic starter. This controller automatically starts the synchronous motor on reduced voltage, closes the field switch at the proper moment and then switches the motor to the full line voltage.

The starters for the wound-rotor motors are of unusual interest. They are shown in Fig. 1. The four controllers are mounted together in the basement, adjacent to the wound-rotor motors that they control, two of which can be seen at the left in the illustration just referred to. The controllers are the Allen-Bradley type J-3230 and provide both time-limit and current-limit acceleration of the motor. This type of controller uses compression-type resistors, which are placed in series with each phase of the rotor of the induction motor.

The operation of the controller is simple. Pushing the start button closes the primary switch, connecting the motor to the line. The closing of this switch also starts the pilot motor which is located at the



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bottom of the control panel and is used for compressing the resistors. The pilot motor rotates a camshaft that compresses the resistors (connected in series with the rotor), until the wound-rotor motor starts. The current relay which is connected in series with the primary circuit and which is set for the maximum desired starting current, then governs the acceleration of the motor. If the primary current rises above the predetermined value for which the relay is adjusted, the latter will act to stop the pilot motor. However, as soon as the current is reduced, due to the acceleration of the motor, the relay will close and start the pilot motor again, thereby further compressing the resistors, which decreases the value of resistance in the secondary of the motor. This action is continued until the motor has been fully accelerated and the resistance short-circuited by a contactor on the panel.

The gearing of the pilot motor to the camshaft is so arranged that approximately 5 to 8 sec. are required to turn the camshaft from the full-resistance position to the lowest-resistance position, if the action is not interrupted by the series relay. The additional time required for bringing the motor to full speed is allowed for by this relay. Consequently, a definite minimum time for starting the motor is provided by the controller, which insures that no undue shock or strain is thrown upon the equipment during the starting period and if unusually high starting torque is required, current-limit acceleration takes care of the acceleration until the motor is thrown across the line.

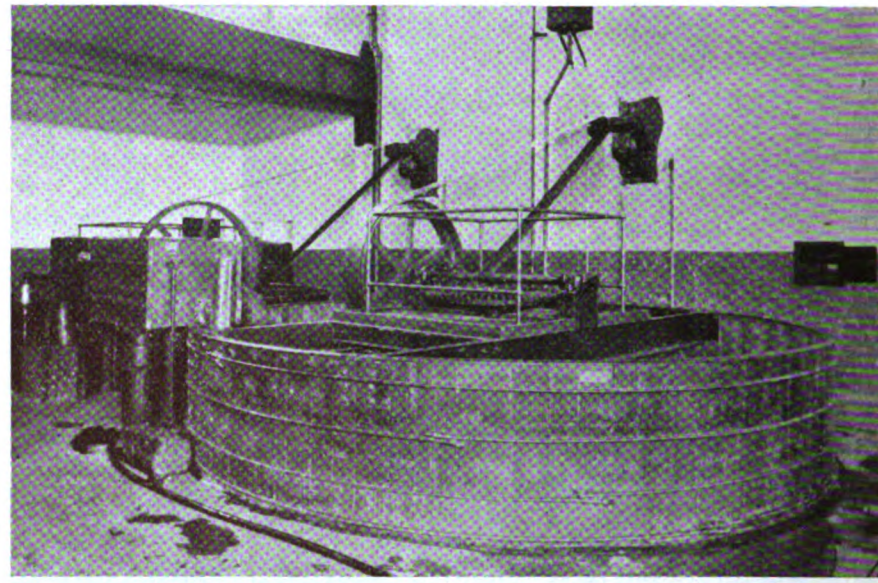


Fig. 7—Back-geared motors are belted to the stuff chests and to the agitators.

This permits mounting the 7½-hp. squirrel-cage motors on the wall, thereby keeping this equipment clean and dry.

Push buttons for starting and stopping these motors are located on the wall adjacent to each beater.

A wattmeter calibrated in horsepower is also located at each push-button control station, so that the operators can know the condition of the load on the individual motors, thereby enabling them to judge the quality of product being produced by the machines. The wattmeter and push-button stations are arranged in sheet-iron cabinets, one of which can be seen at the extreme right of Fig. 9. A close-up view of a similar control station can be seen in Fig. 3.

There are 34 power drives in the machine room and in the basement under it. It is in this room that the pulp is put through the Jordan engines for refining. It then passes on to the paper machine where the liquid paper stock or pulp is converted into paper.

Inasmuch as the load on the Jordan engines can be reduced as much as desired when starting, they are driven by synchronous motors which are directly connected thereto. The

Table III—Drive Data of the Equipment Used in the Machine Room

Machine Driven	Type	Rating Hp.	R. P. M.	Motor Mfg.	Type of Control	Control Mfg.	Method of Drive
No. 1 Jordan	Synchronous	200	360	Elect. Mach. Co.	Automatic	Elec. Con. & Mfg.	Direct
No. 2 Jordan	Synchronous	200	360	Elect. Mach. Co.	Automatic	Elec. Con. & Mfg.	Direct
No. 1 Agitator	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Reduction gear
No. 2 Agitator	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Reduction gear
Constant-speed drive	Squir. cage	125	585	Crocker-Wheeler		Allen-Bradley	Belt
Motor-generator	Synchronous	230	1,200	Crocker-Wheeler	Automatic	Allen-Bradley	Direct
Variable-speed machine	D. C.	200	600	Crocker-Wheeler		Allen-Bradley	Belt
Rewinder	D. C.	25	335/1,000	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Stuff pump	D. C.	7.5	300/600	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Stuff pump	Squir. cage	7.5	535	Elec. Con. & Mfg.	Compensator	Elect. Con. & Mfg.	Belt
Wire shake	D. C.	0.4	450/900	Crocker-Wheeler	Automatic	Allen-Bradley	Belt
Oil pump	D. C.	0.25	1,725	Western Electric	Safety switch	Square D	Direct
Oil pump	D. C.	0.25	1,725	Western Electric	Safety switch	Square D	Direct
Monorail crane	D. C.				Manual	ShephardC.&H.Co.	Gear
Consistency regulator	Single phase	0.1	1,750	Robbins & Myers			
Oil pump	Squir. cage	2	1,155	General Electric	Across-the-line	Allen-Bradley	Gear
Beater room pump	Squir. cage	25	1,740	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Machine pump	Squir. cage	25	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
No. 3 Agitator	Squir. cage	7.5	850	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Speed reducer
Four heaters	Squir. cage	3	1,140	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
Four heaters	Squir. cage	2	1,135	Allis-Chalmers	Across-the-line	Allen-Bradley	Belt
Elevator	Squir. cage			Warner Elev. Co.			Flex. coupling
Seybold cutter	Squir. cage	7.5	1,140	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Belt
Water pump	Squir. cage	10	1,150	Allis-Chalmers	Auto. prim. res.	Allen-Bradley	Flex. coupling
Ventilating fan	Squir. cage	15	1,150	Allis-Chalmers	Compensator	Allis-Chalmers	Belt
Breast roll hoist	D. C.			General Electric			Direct

Direct-current motors are for 230-volt service.
All other motors are for 440-volt, three-phase service, except the single-phase motor, which is connected to the 110-volt supply.

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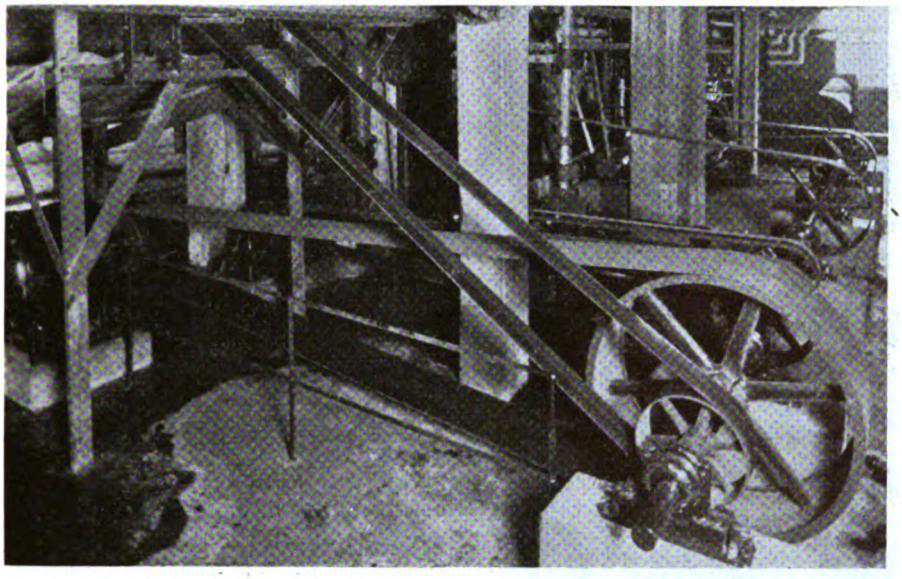


Fig. 8—Group drive is also used on the constant speed drive.
A Crocker-Wheeler, squirrel-cage, induction motor drives this lineshaft, which in turn drives a group of seven pumps used on the wet end of the machine.

two Jordans are driven by Electric Machinery Co. motors rated at 200 hp., 360 r.p.m. They are controlled by push-button-operated, automatic starters made by the Electric Controller and Mfg. Co. One of the Jordan engines together with the push-button control station is illustrated in Fig. 3.

The main drives on the paper machine proper are the constant-speed drive and the variable-speed or Ward Leonard drive. The constant-speed drive operates one water pump, two large vacuum pumps for the suction rolls, and four small pumps for suction boxes, all of which are located in the machine room basement. Inasmuch as these seven pieces of equipment must operate simultaneously (for a shutdown of any one would mean that the entire paper machine must be shut down), group drive was selected as being the most economical in operation and first cost. The constant-speed drive is illustrated in Fig. 8. It consists of a 125-hp., 585-r.p.m., Crocker-Wheeler squirrel-cage induction motor belted to a lineshaft running in ball-bearing pillow blocks mounted on concrete pedestals resting on the basement floor. Inspection of Fig. 8 will show how the use of belts lends itself to driving of pumps, etc., which must be driven at various speeds and be located at different distances from the lineshaft, due to limitations caused by piping and building columns.

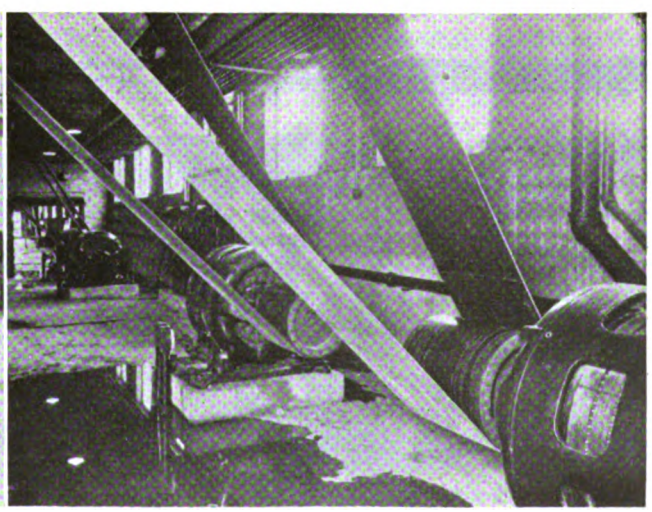
The variable-speed or Ward-Leonard drive consists of a motor-generator set (shown at the right in Fig. 11) supplying variable-voltage direct current to a shunt-wound motor belted to a long lineshaft which, in turn, is belted to the seven sections of the paper machine on the floor above. The shunt-wound motor and the long lineshaft which are located in the basement beneath the machine room, are shown in Fig. 2. This lineshaft also runs in ball-bearing pillow blocks supported in the same manner as those for the other lineshafts. The motor, which is shown at the left of the illustration just mentioned, is equipped with two sizes of pulleys on the armature shaft which may be belted to two different sizes of pulleys on the lineshaft, thereby obtaining two ranges of speed. These two changes combined with the change in speed by the manipulation of the generator and shunt motor fields, give a total range from 80 to 800 ft. per minute on the paper machine.

The lineshaft just mentioned is belted to countershafts on the floor above, which in turn are geared to the different sections of the paper machine. To enable any section of the paper machine to be cut out, Cutler-Hammer magnetic clutches are provided on each countershaft to disconnect the pulley from the gear.

The control for the machine room has been grouped together as shown in Fig. 11. The two panels at the extreme right are the Allen-Bradley control for the motor-generator set shown in the right foreground and for the variable-speed shunt motor. The third panel from the right is

Figs. 9 and 10—Belt drive is used for the beaters.
Fig. 9, left, shows the four beaters that are individually driven by the wound-rotor motors shown in Fig. 10, right. The sheet metal cabinet at the extreme right of Fig. 9 contains a horsepower meter and the start and stop buttons for No. 4, beater. A similar cabinet is located adjacent to each beater. These buttons operate the controllers shown in Fig. 1.





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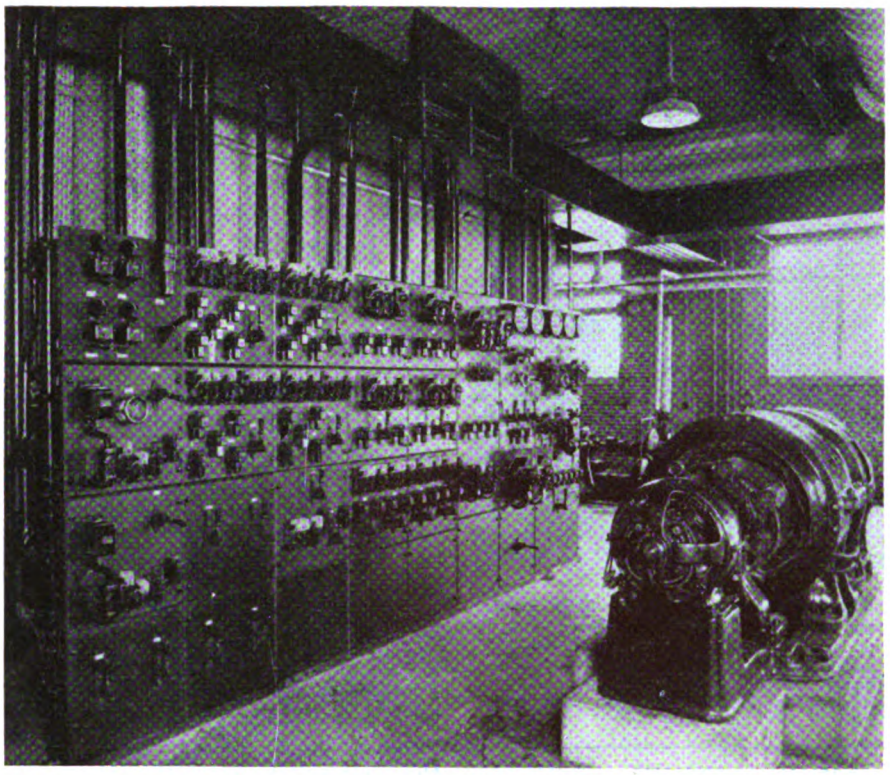


Fig. 11—Large junction boxes located over the control boards greatly simplify the conduit layout.

Sections of one side of the boxes are hinged as shown so as to permit ready inspection of the wiring. The wires are carried on racks inside of the junction box, as may be seen. This control board contains all of the controllers for the machine room. The motor-generator set at the right furnishes the variable-voltage supply for the variable-speed, paper machine drive.

the control for the constant-speed drive motor. The remaining panels are for the various auxiliary drives in the machine room and are listed in Table III.

As has been said before, push-button control is used throughout. One of the push-button stations is shown in Fig. 3. Directly above the push buttons are two wattmeters calibrated in horsepower so as to give the operator an idea of the amount of power being drawn by the machines controlled by the push buttons. These meters are used in adjusting the amount of shredding that each Jordan does whether they are connected in series or parallel. It also provides a means of setting the machine to duplicate a product previously produced. In this connection, it may be said that similar meters are used on all of the larger drives throughout this plant, with the idea that these would help the operators to set their machines to duplicate conditions that have formerly been obtained. Careful readings are taken on these meters for every grade of paper that is put through.

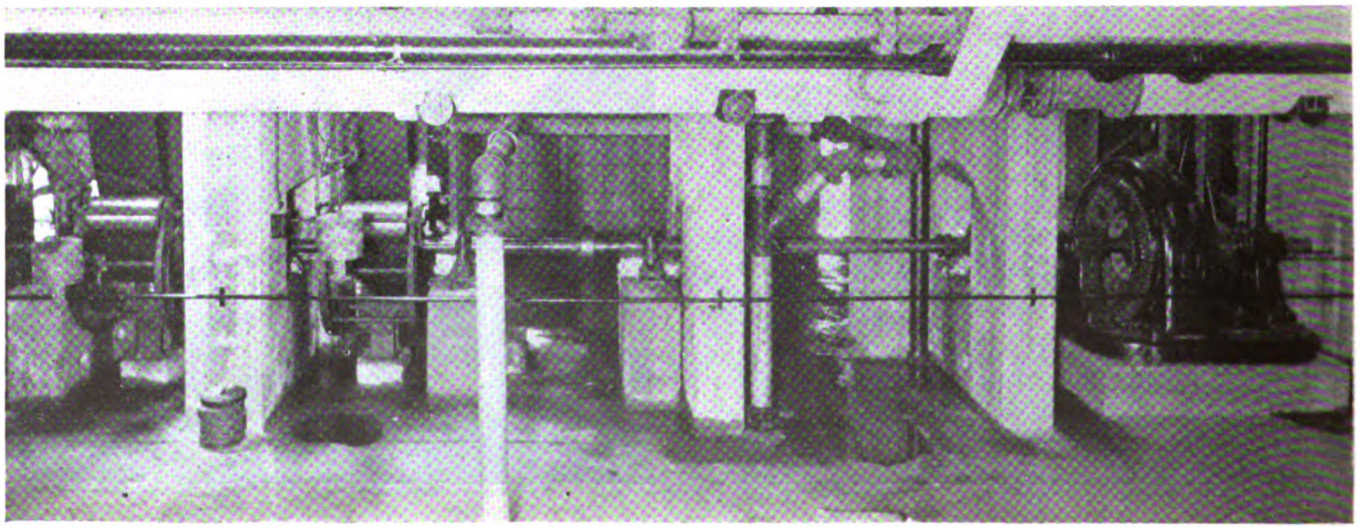
This mill has a connected load of 583 hp. in squirrel-cage, induction motors, 590 hp. in wound-rotor motors and 895 hp. in synchronous motors. For normal operation the four wound-rotor motors on the beaters would be shut down, thereby giving a total connected load of 833 hp. in induction motors as compared with 895 hp. in synchronous motors. As might be expected from such a combination the power factor is very high, in general averaging about 95 per cent.

With the exception of the motors on the beater drives, practically all of the squirrel-cage and wound-rotor motors were furnished by the Allis-Chalmers Mfg. Co. Thirty-five of these motors are equipped with Timken roller bearings. A saving in maintenance and repair expense, less oil trouble and less greasing is expected through their use. So far the bearings have operated for eight months with absolutely no trouble whatsoever.

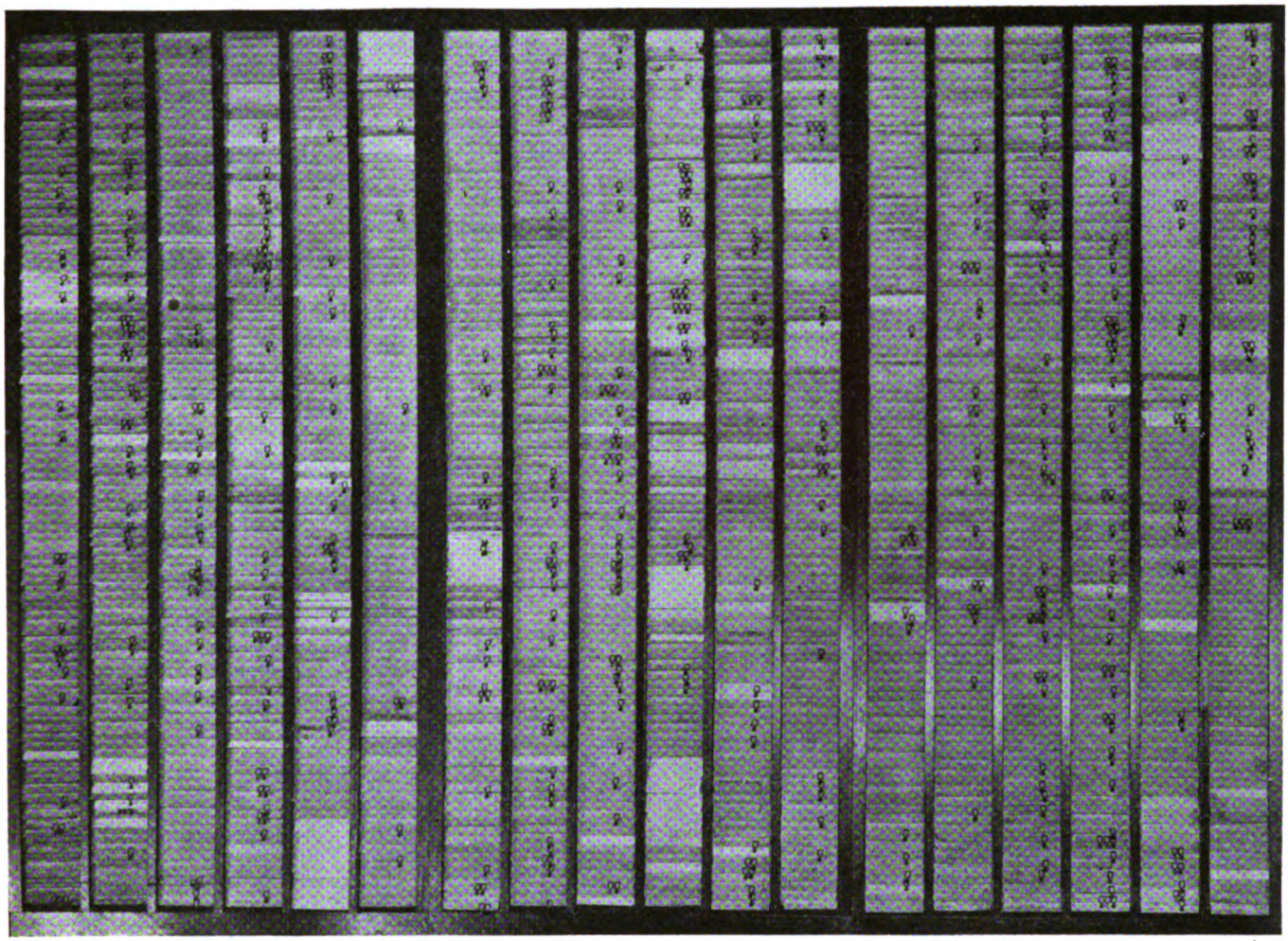
These bearings, together with the ball bearings in the lineshaft pillow boxes, are equipped with Alemite nipples for the Alemite system of pressure lubrication. No grease has been put into the motor bearings since the time of installation, although the motor bearings have been inspected from time to time. Every indication points to the fact that greasing will be required only at yearly intervals.

Fig. 12 — A synchronous motor drives a group of four beaters through a lineshaft.

The synchronous motor is coupled directly to the lineshaft. A Lenix Drive, as shown at the left, is used on each lineshaft pulley to permit the belts driving the beaters to hang slack during starting or for independently stopping any beater. Use of the Lenix Drives also makes it possible to place the lineshaft directly under, and at a short distance from, the beater pulleys.



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The cards in this rack give a visual record of the operation of more than 3,000 motors in a large steel plant. Only three of the total of five sections used, are shown. Each section contains 600 cards. The cards are filed vertically in rows according to the location of the motors they represent. The name of the foreman in charge of a division is placed at the beginning of the corresponding section in the rack.

Ways in which a

Visual Record System for Motor Failures

enables the man responsible for the operation of a large number of motors to check their performance and thereby reduce the number of production delays occurring on them

By COMER D. HAZEN

Asst. Chief Electrician, Youngstown Sheet & Tube Co., Youngstown, O.

HAVE YOU EVER wanted to know quickly just how many motor failures you had in a given time and where these failures were? Have you wished for something like a map, upon which you could look and say, "I have had four failures here, two over there and only one at the other place?" Mr. Hazen, herein describes a system which in reality is a map of the motor casualties on the battlefield of operation. His system is simple yet it gives him an accurate picture of what is going on among 3,000 motors in his plant.

MOST motor record systems are made up in the form of cards which are filed in cabinets or drawers. On these cards more or less complete data is given regarding the motor and the machine driven by it. When ordering spare parts or determining rewinding data for the motors, such a record is very convenient for it provides a complete record of the details regarding a given motor. Some systems also provide a space for recording the failures on the motor and the cost of the required repairs. This is of value in determining the cost of operating a motor on a certain machine or in a certain location. However, the information is hidden away and, in case of a large number of motors, it is necessary to go through many cards in order to determine the frequency of motor failures.

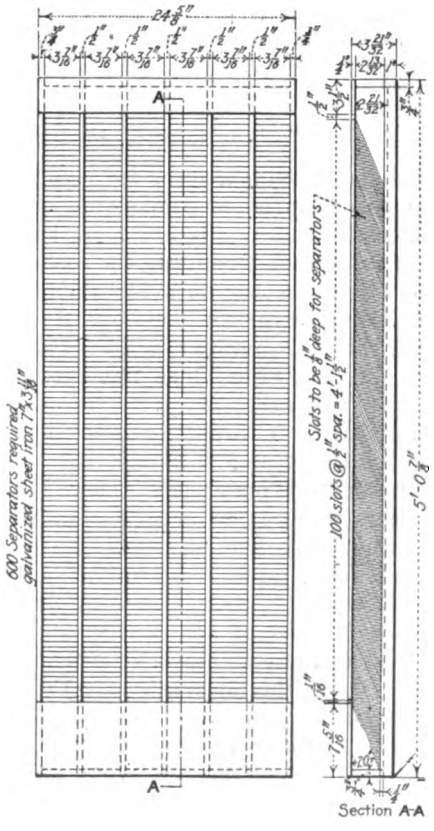
In a steel plant, the most important thing is to keep the motor running. The man in charge of the maintenance and operation of the power drives is judged more or less by the number of delays that occur on the equipment he is responsible for. Hence, the important fact to be recorded is how many times each motor has failed in service within a given length of time and what were the causes of these failures.

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With this idea in mind a visual record system for motors was devised that would enable the man responsible for their operation to check their performance at a glance. It consists essentially of a rack accommodating 3,000 cards, which hangs on the wall of the office of the *Electrical Department*. This rack is very similar to the racks used in timekeeping departments for holding the time cards. It occupies a space 5 ft. high and 10 ft. wide. The rack is built in sections, each section holding 600 cards, as shown in the illustration on page 517. Each section is made of a wooden frame composed of seven vertical strips held at the top and bottom by horizontal strips. The vertical strips are slotted at an angle as shown in the working drawing on this page, so as to hold galvanized iron separators, which make the pockets in which the cards are kept. Careful inspection of the working drawing just referred to and the illustration of three sections of the rack shown on page 517 will give a clear idea of the construction. Each pocket is inclined slightly off the vertical so that the cards are held upright with only a half-inch of the top of each card visible. By inclining the cards, as described, the pockets fit behind each other in such a manner that from the front all that is visible is vertical rows of cards, as shown in the illustration on page 517.

Five sections made up like this compose the rack for holding the record cards.

Each section of the rack is made of seven vertical wood strips held at top and bottom by horizontal wood members, as shown in the left-hand view. The vertical strips are slotted ⅛ in. deep at an angle as shown in the right-hand view, which is a side elevation of the rack. Galvanized iron separators are held between opposite slots on the adjacent vertical members, as shown in the left-hand view. The back of the rack is tightly closed in by boards as shown at the right.



The record cards used in this system are 3¼ in. wide by 7½ in. long and are made up as shown on this page. In the upper left-hand corner is a space for the number designating the drive on which the motor is used. This designation consists of two letters indicating the plant division in which the drive is located, and the number of the motor. For instance, PL 64 indicates motor No. 64 in the plate mill; SM 19 indicates No. 19 drive in the sheet mill, and so on. The latter drive happens to be on a crane; so there are three cards with this same number—one for the bridge motor, another for the trolley motor, and a third card for the hoist motor. In a case of this kind all three cards go in the same pocket of the rack. Hence, each pocket in the rack represents one complete drive application.

Beneath the numbers just mentioned, spaces are provided for recording the name of the department in which the motor is located, manufacturer's name, character of field winding, class, form, horsepower, voltage, amperes, frame number, and speed of the motor. There is also a place for recording the brushholder data, and the number, size and make of brushes. Below these data is a place for writing in the name of the particular application the motor drives. The remainder of the card is used for recording the date of the motor failures and the reason for each failure.

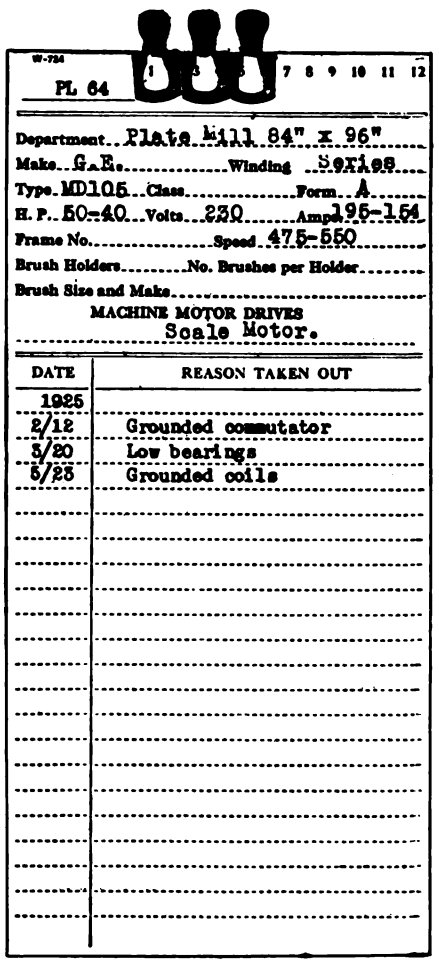
After making a motor or armature replacement, the foreman in charge of that division in which the delay occurred, makes a note of the failure in his daily report, telling the reason for the failure and the length of the delay. The clerk in the *Electrical Department* receives this report the following morning and enters all failures immediately on the cards just described. When the first failure occurs he places a black tab on the cards, as shown in the illustrations. On the occasion of the second failure, a green tab is placed beside the black one and thereafter for every failure during the remainder of the year an additional red tab is attached to the card. At the end of the year, the slate is wiped clean, all the tabs are removed and a new start is made.

As the cards sit in the racks only the motor location number and the colored tabs are visible; hence the attention of the electrical superintendent is quickly drawn to any cards that show troubles or delays. The cards are arranged in the racks according to the geographical divisions of the plant and at the start of the row of cards for each district is placed the name of the foreman having charge of the motors in that division. In this manner the electrical superintendent has a visual

(*Please turn to page 554*)

Colored tabs are used to indicate the number of motor failures.

On this card are recorded the data regarding the motor, the location of the drive and the name of the machine it drives. In the lower half of the card, the dates and reasons for motor failures are tabulated. When the first failure for the year occurs, a black tab is placed at the top of the card, as shown. On the second failure, a green tab is placed beside the black one, and for every failure thereafter during the remainder of the year, an additional red tab is placed on the card.


W-734

PL 64

1 2 3 4 5 6 7 8 9 10 11 12

Department Plate Mill 84" x 96"

Make G.E. Winding Series

Type MD105 Class Form A

H. P. 50-40 Volts 230 Amps 195-154

Frame No. Speed 475-550

Brush Holders No. Brushes per Holder

Brush Size and Make

MACHINE MOTOR DRIVES

Scale Motor.

DATE	REASON TAKEN OUT
1925	
2/12	Grounded commutator
5/20	Low bearings
5/25	Grounded coils

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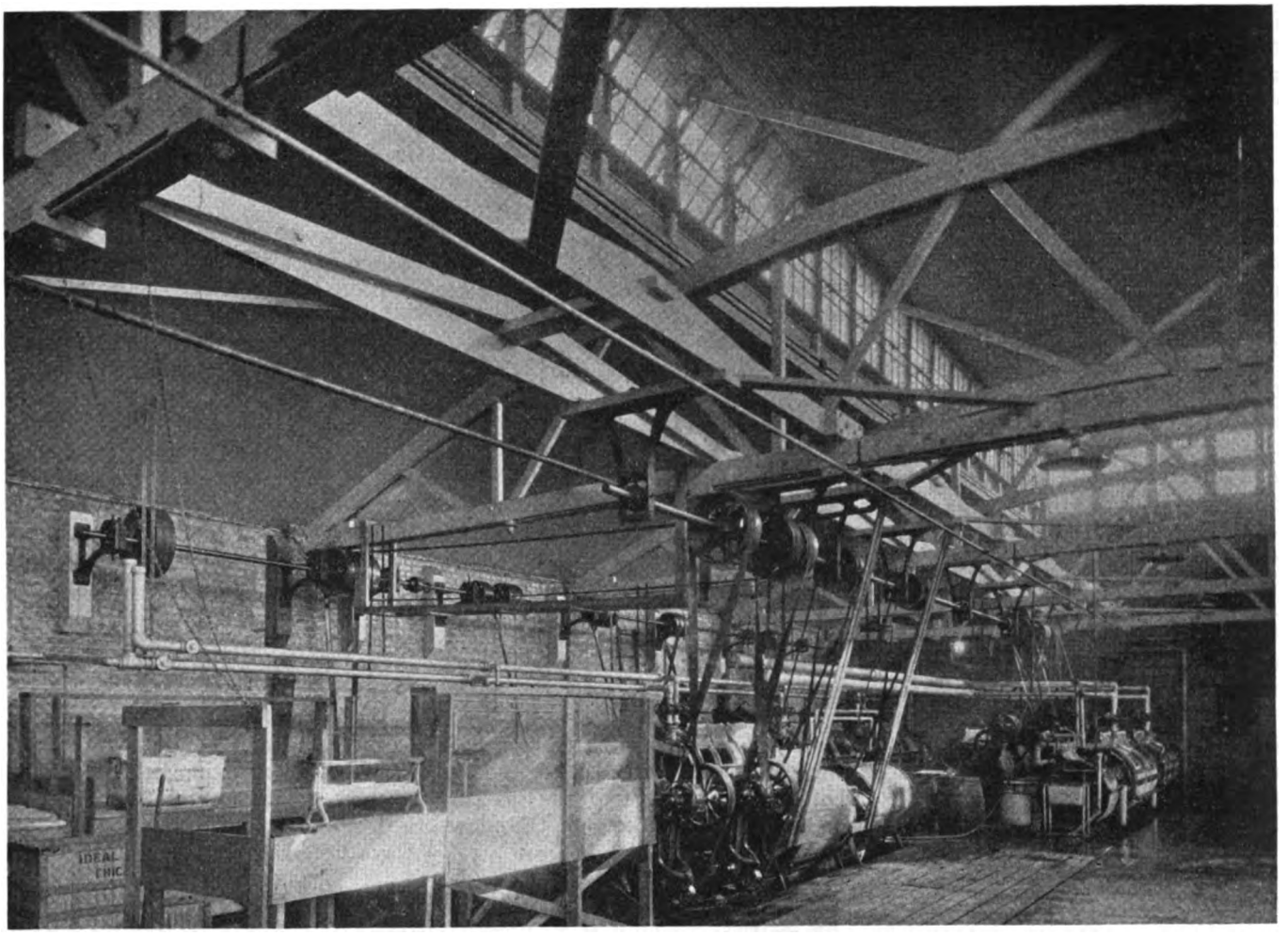


Fig. 1—Buildings with wooden roof truss construction present some of the most difficult problems met in erecting lineshafts. This special truss extending between the roof trusses, and on which the shaft is mounted, has been found to be very substantial.

Practical pointers on the

Groundwork Necessary Before Erecting a Lineshaft

so that it will be rigidly supported and will maintain proper alignment in concrete, mill construction and other types of buildings

By GEORGE TRIMM

Millwright Superintendent, Chicago Pulley & Shafting Co., Chicago, Ill.

ERECTING a lineshaft is a job which requires at least experienced supervision. Also, with experienced millwrights the construction can go up quicker, better, and cheaper. In such work as this, much depends upon the knowledge and previous experience of the men, as it would be difficult and almost impracticable to attempt to work out by mathematical formulas the strength of the various constructions and of the bracing and lagging necessary. Also, so much depends upon the freedom from vibration and sagging of the building that good judgment in placing the bracing is often more necessary than actual strength of materials.

Some of the important points always to keep in mind in the preliminary construction or groundwork before the erection of a lineshaft depends so much upon the type of the building that they are more easily explained by connecting them to specific examples, some of which are given later in this article.

There is hardly any type of building construction which is not encountered when erecting lineshafts, even though it was never originally intended to bear the extra weight. This is particularly true in Chicago, and probably other large cities, where buildings which were originally erected for garages, single-story buildings built for floor storage, stores, lofts, and even offices are later used for laundries and so-called light manufacturing, which sometimes makes heavy demands upon the construction. These types of building construction cause probably the most difficult problems in connection with the erection of a lineshaft and will be discussed more fully later.

In some ways substantial, mill-construction buildings are the easiest in which to erect a lineshaft. The problem becomes more difficult as the quality of the construction decreases. Reinforced concrete construction has a good, substantial ceiling for erecting a lineshaft. Saw-toothed roof buildings offer a

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problem of construction similar to that encountered with other trussed roofs. Each of these types will be discussed more fully later in the article.

A good example of a lineshaft installation in a mill-type building is shown in the illustration in Fig. 7. This shows part of a 100-ft., 2 15/16-in. lineshaft at the Chicago plant of the Wolff Mfg. Co. This shaft is to be driven by a 30-hp. Allis-Chalmers motor and will operate at 209 r.p.m. The five 20-ft. lengths of 2 15/16-in. turned and ground shaft are connected by Griptite keyless, compression couplings. A 44-in. by 10-in. Oneida split-steel pulley is also clamped on the shaft with a keyless, cast-iron bushing bored to clamp fit. Cast-iron, four-point adjustable, drop hangers with a 22-in.—24-in. frame are spaced 8 ft. apart, which is standard spacing for practically all cases except on shafts operating under severe service, or where a shaft is small for its load, or where a number of additional pulleys and loads are added and it becomes necessary to insert additional hangers about midway between the hangers already installed. An example of this will be given later.

In this installation the driving pulley is placed at the center of the shaft, which will be approximately the center of the driving load. The hangers on each side of the driving pulley are placed 4 ft. apart, which will eliminate any possibility of whip or weave due to the pull of the belt. This shaft is to be used to drive a double row of buffing and polishing wheels and, as laid out, will not drive enough machines to equal its capacity. It is a good plan to provide greater capacity in such installations than is necessary for the machines planned for the initial installation as practically always more machines are added later. An extra ⅛ in. or ¼ in. in the diameter of the shafting costs comparatively little more and practically nothing more for erection.

In the case of this installation at the Wolff plant, Fig. 7, the building is of substantial mill construction and the ceiling practically level, so that the actual job of erecting the shaft was comparatively simple. The footings which support the hangers were made of 3-in. by 10-in. yellow pine plank. The ceiling beams are spaced about 36 in. center to center and the footings are fastened on with four ⅝-in. by 7-in. lagscrews. Holes 11/16 in. in diameter were bored in the cleats or footings and ½-in. holes in the joists for the lagscrews.

In erecting lineshafts in mill-constructed and most other multi-story buildings, a point which may cause difficulty is a ceiling construction which is too light, so that the ceiling gives with passing loads on the floor above, or when material or machines are placed on the floor above. In such a case as this a good practice is to install and line up the shaft under the conditions as found at that time. In about a month or so, it is well to go over the shaft again and line it up to see if there has been any deflection in the ceiling which has affected the shaft. This will take care of the loading caused by, machines on the floor above.

In case the ceiling gives with a passing load, little can be done to remedy it. However, where the floor above is used for storage, it is best to realign the shaft every time the floor is filled up or emptied as in some cases deflections of over an inch have been found in the center of the ceiling span. Lineshafts which are an inch out of alignment will create a very heavy friction load in the bearings.

Another serious problem in any installation arises where the joists are uneven. In such a case it is necessary generally to put some blocking under the footing at one end or the other. The best way to get this footing square is to use a plumb-bob or a vertical level and a T-square. Sometimes it is possible to level the footing on the top side, if it is finished lumber; this would have been possible with the shaft installed in the Wolff plant if it had been necessary.

In case the roof or ceiling slopes toward one end of the building, a type of construction which is frequently found on the top floor of loft buildings, it is practically always necessary to work from a line

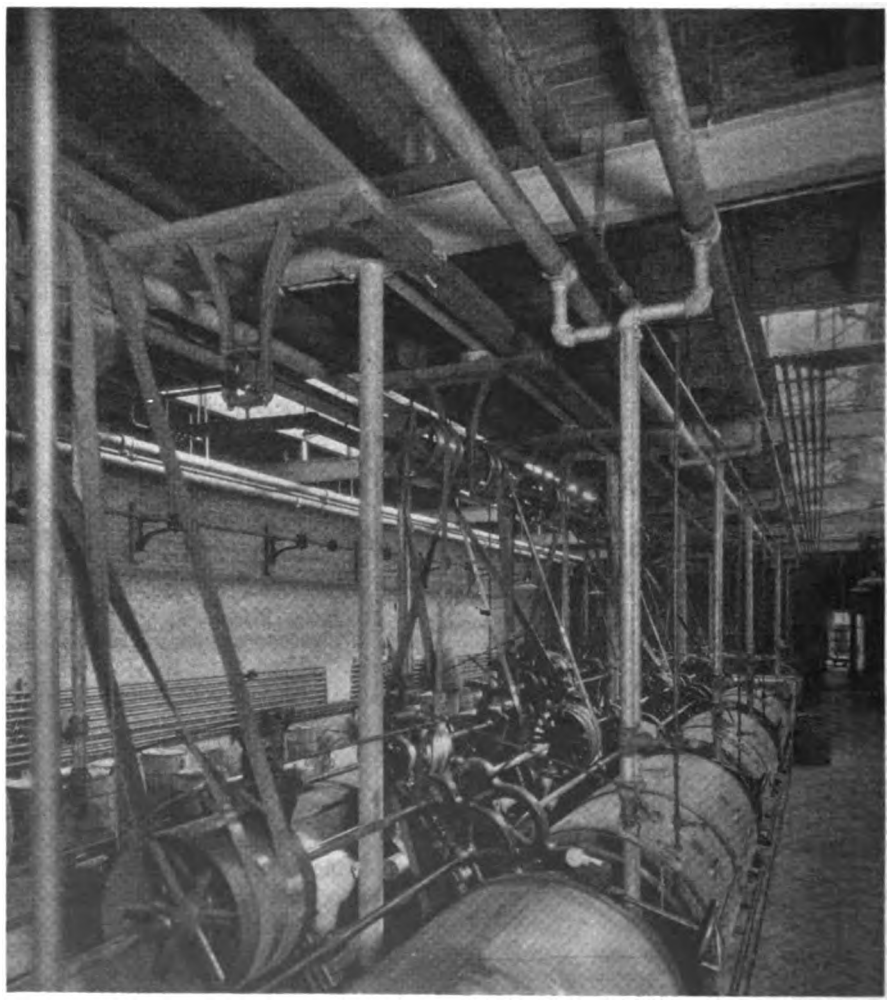


Fig. 2—In the installation at the Alert Wet Wash Laundry, Chicago, Ill., it was possible to fasten each footing to an I-beam with beam clamps.

In addition, the footings were fastened to the ceiling by special stringers. The method of extending a shaft over the light-well in the center of the building is shown in Fig. 3.

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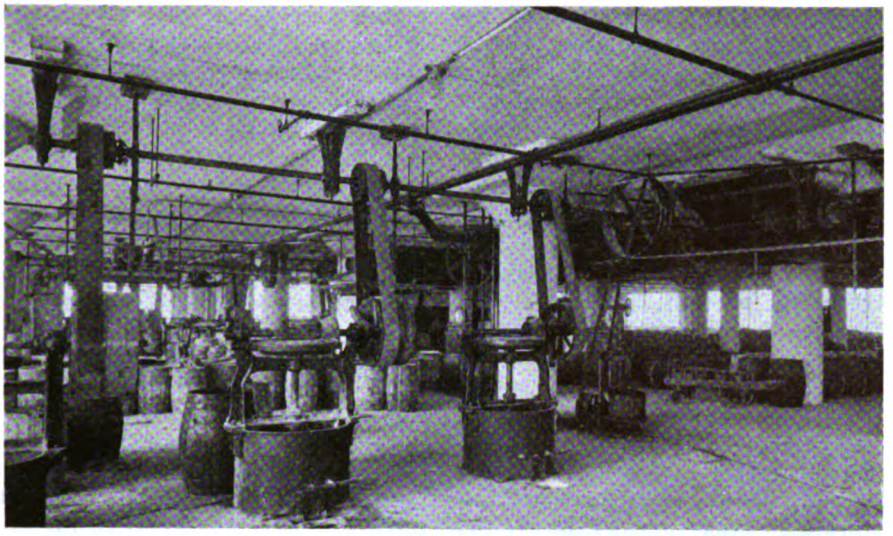


Fig. 5—This is a view of a different part of the paint mill shown in Fig. 8. This type of lineshaft installation is used throughout the plant.

Here the footings for the lineshaft are fastened to the concrete ceiling by expansion shells and the hangers are bolted to these footings. Concrete buildings give probably the most substantial supports to a lineshaft.

stretched from one end of the buiding to the other, or the length of the shaft. The line is leveled by the use of a line level, which is a small, light and very sensitive level which may be hung on the center of a taut line without deflecting it perceptibly. By working from this line it is possible to measure to the ceiling at each of the varying heights and build up the necessary blocking so as to provide a substantial footing for the lineshaft.

To make this footing more substantial it is generally advisable and practically always necessary to run stringers the full length of the shaft and fasten the hangers to the stringers or to footing blocks bolted to the stringers. An installation of this kind where the roof has a considerable slant is shown in Figs. 2 and 3; these illustrations were taken in a laundry. In cases of this sort 2-in. by 8-in. or 2-in. by 10-in. planks are commonly used for the blocking, with 4-in. by 4-in. or 4-in. by 6-in. timbers as stringers.

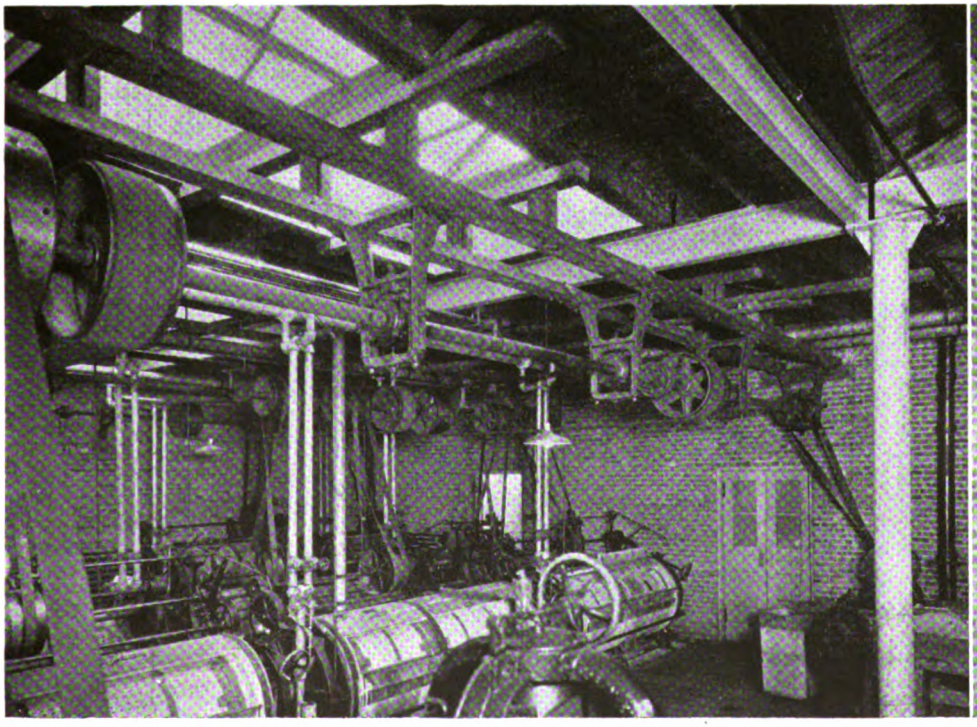
If, in the installation at the Wolff plant, it had been necessary to extend the lineshaft at a right angle to that shown in the illustration, so that it would cross the joists instead of running in the same direction, it would have been necessary to lay stringers across the joists and lagged to them. The footings would then be bolted to the stringers. It would be advisable to lagscrew stringers to the joists on each side of the footings.

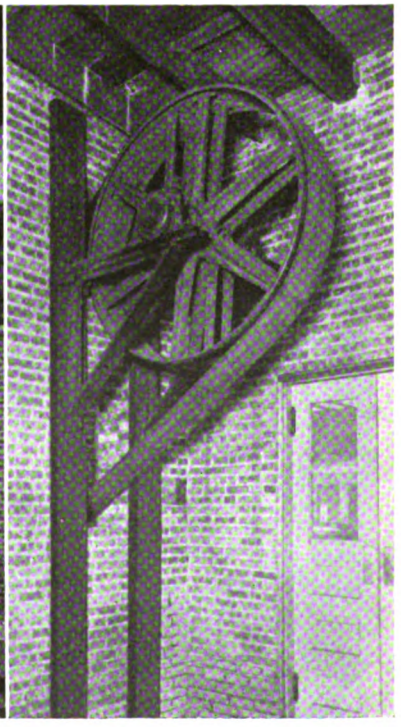
Sometimes it is necessary to run shafts diagonally across a ceiling, as is shown in Fig. 6. The construction is shown clearly in this illustration. A series of parallel shafts belted to each other is more expensive to erect than a single shaft but frequently the layout of the machines makes it necessary. This is often the case in long, narrow buildings.

In case of a building with laminated floor construction, that is, where the floor and ceiling are made up of 8-in. or 10-in. planks on edge, nailed together, it is extremely difficult to erect a lineshaft on the ceiling so that it is not subject to a "weave" transmitted by trucking or any motion or vibration of machines on the floor above. In such cases

Figs. 3 and 4—These illustrations show the mounting of the main drive shaft, at the other end of the room shown in Fig. 2.

This ball-bearing main drive shaft extends through the wall at the door to a main driving pulley which is belted to an engine; the method of mounting the shaft at the driving pulley is shown at the right. Fig. 3 at the left, shows a special staging which is necessary to carry the lineshaft across under the lightwell. Where possible the stringers were clamped to the I-beams, although this alone was not sufficient. Fig. 4, at the right, shows how wall brackets and ball-bearing pillow blocks may be used to mount a shaft along a partition wall, and the bracing which was necessary to prevent the wall giving under the load of the shaft and pulley.





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it is best to lay stringers and lagscrew them to this ceiling. Footings are then attached to the stringers by lagscrews.

We believe that it is advisable to use footing planks for attaching hangers as they not only give a substantial base from which to work, but also permit the use of a bolt instead of a lagscrew for attaching the feet of a hanger. This permits making adjustment by shifting the feet at any time without loosening the thread made by the lagscrew.

We use a tight line as a base for practically all our work. This is leveled by the use of a line level and if over about 40 or 50 ft. long is generally supported in the center so that it will eliminate errors which might creep in due to sag. A large proportion of the objections to the use of a line is due to the fact that the men using it are not experienced enough and do not exercise sufficient care to see that it is level.

Perhaps one of the most difficult types of construction for supporting a lineshaft is in buildings with a frame truss roof support. A typical installation in a building of this type was made at the Ideal Wet Wash Laundry, Chicago, Ill., as shown in Fig. 1 at the beginning of this article. Another type of construction for supporting lineshafts under similar conditions is to lay 6-in. by 6-in. stringers from one truss to the next and to support the lineshafts on footings attached to these stringers. This type of construction, however, is subject to the natural sag due to the weight of the shaft, with a consequent misalignment of the shaft.

A better form of truss which is easily constructed and installed is shown in this illustration of the Ideal Wet Wash installation, Fig. 1. This truss which may be seen extending between the first two roof trusses in the foreground of the illustration is made of 2-in. by 6-in. and 2-in. by 8-in. planks with cross braces, and bolted together as shown. Diagonal braces extend from the side of this brace to the roof truss to prevent side-sway. The footings for the hangers are bolted to this special truss.

In this construction, a special truss is put up between each of the roof trusses. Each of these is bolted together at the ends and with the side bracing does not show any vibration even under the severe service in a laundry. Laundry service is severe in that a washing machine makes a certain number of revolutions in one direction, then reverses, makes the same number of turns in the opposite direction, and repeats this continuously. This is a 1 15/16-in. turned and ground shaft 40 ft. long and equipped with SKF ball-bearing hangers.

Still another type of construction was required in the installation of the lineshaft which is attached to the back wall, as also shown in Fig. 1. This is also 1 15/16-in. lineshaft, 60 ft. long, and is supported by SKF bracket hangers. The footings here consist of 6-in. by 6-in. pieces of timber which are bolted to the wall with the bolt head held by a steel plate on the outside of the wall. One of the most important points to consider in attaching hangers to a wall is to provide a substantial footing so that the hanger will have a base of sufficient size so that it is mounted firmly and on a large area of brick wall. The mere size of the timbers is not the important point, however; it is more important to see that they are placed where they can be used to best advantage.

In the lineshaft installation made at the Alert Wet Wash Laundry, Chicago, Ill., Fig. 2, the roof is supported on steel I-beams, which in turn are supported on cast-iron posts. This offers a still different problem. Here the footings for the hangers are supported partially by an I-beam supporting the roof joists and extending parallel to the shaft. In addition, 3-in. by 8-in. stringers are extended alongside the I-beam and bolted up to the ceiling, with special bracing. This is shown more clearly in Fig. 3, which was taken in the same laundry at the other end of the room, at the main drive shaft. How this footing is clamped and attached to the I-beam is shown in the second hanger in this illustration. Here a block under the footing is attached to the I-beam by beam clamps which are bolted to the footing and clamp over the flanges.

In a case like this, wooden stringers may be used because they can be supported in several places,

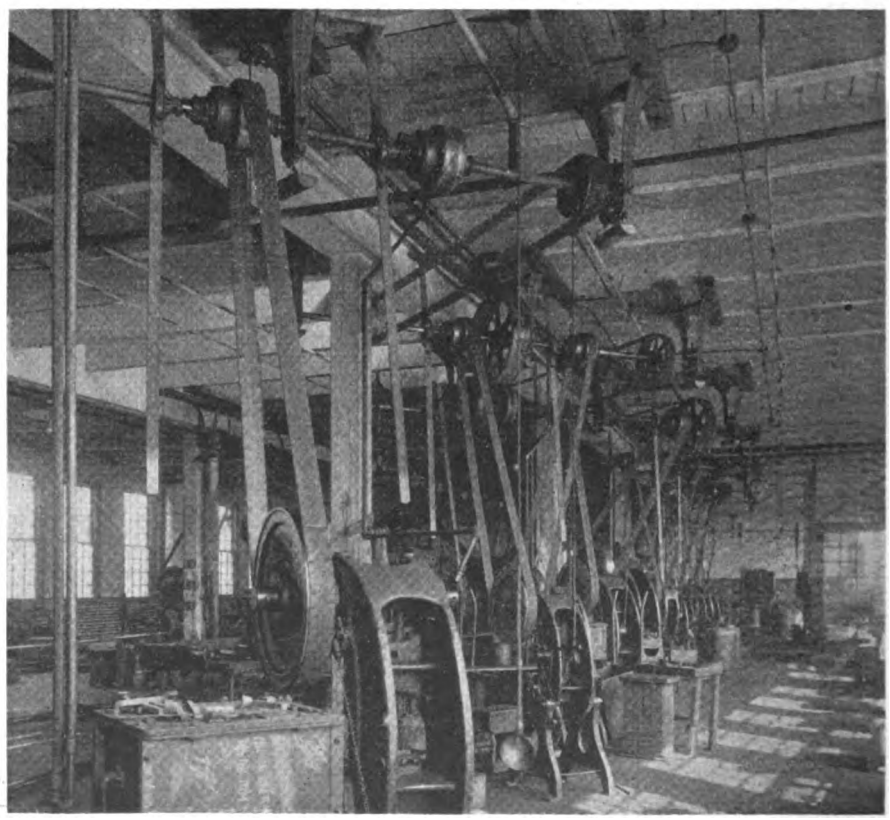


Fig. 6—Method used in installing a lineshaft diagonally across the building.

When it is desired to stagger the machines without using a twisted belt it is sometimes necessary to install a number of parallel shafts, as was done here, with each shaft driving the next. This is a mill-constructed building and the cleats or footings for the hangers are fastened to the joists by lagscrews. It was necessary to use two cleats for each hanger. Instead of countershafts each machine is driven directly from the lineshaft through a clutch pulley. Cutoff couplings permit sections of the shaft to be cut out if necessary. The placing of the lineshaft is generally secondary to the desired placing of the machines. Sometimes in long, narrow buildings, it is necessary to install the machines in rows crosswise in the building. In such cases, it is generally necessary to run a number of rows of parallel lineshafts connected together by belts, using only one motor to drive the group. Wherever possible, in such cases, it is advisable to connect the motor to the center shaft.

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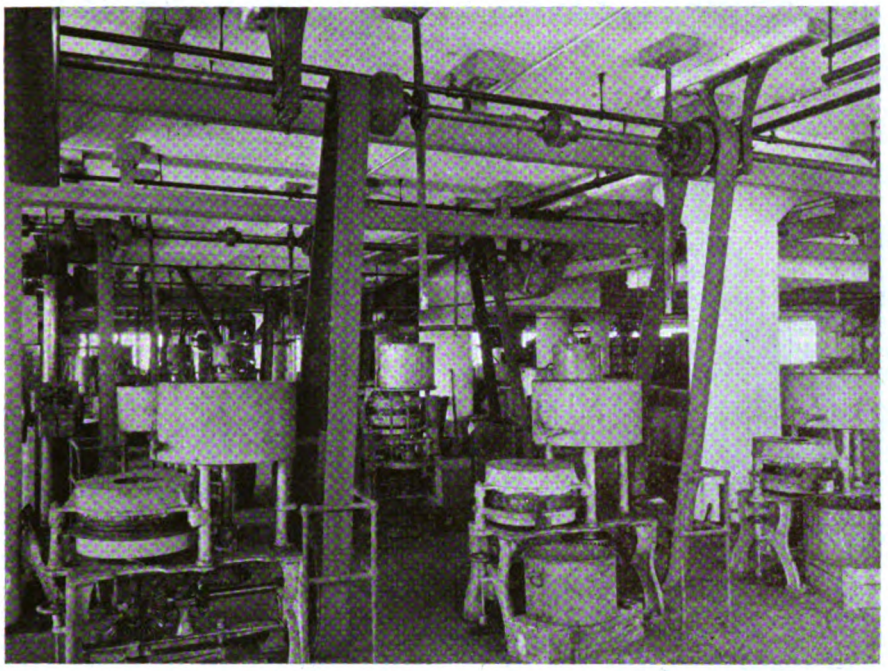


Fig. 8—This lineshaft was installed in a reinforced concrete building.

Here the footings for the lineshaft, clutch shifters, and also footings to support a monorail I-beam are attached to the concrete ceiling by the use of expansion shells. This is a 2 7/16-in. shaft mounted in SKF ball-bearing hangers. Countershafts are eliminated entirely in this installation in a Chicago paint mill by the use of ball-bearing clutch pulleys.

whereas with the wooden truss roof the only possible method of supporting the truss or stringers is at the ends. Also, the method of clamping the hanger footing to the I-beam helps to give added rigidity. This is a substantial method of supporting lineshaft and does not permit any vibration in operation, even under the severe service of the reversing motion of the washing machine.

A lineshaft is supported on the wall in Fig. 2 in much the same manner as was used at the Ideal Wet Wash, shown in Fig. 1. Here, however, the footing is not so heavy because it was not necessary to carry the lineshaft quite so far away from the wall. This footing is also bolted through the wall, with the bolt heads held by steel plates.

Fig. 3 shows the main drive in this same laundry. This illustration shows clearly the method of mounting the stringers and also the beam clamps which are used to fasten this stringer to the cross I-beam. Here it was necessary to insert special staging to cross over a sky-light. The method of construction and blocking necessary may easily be understood from the illustration.

The lineshaft in the background and the one attached to the wall are the same as shown in Fig. 2. This main lineshaft is 2 7/16-in. in diameter and extends through the wall to a 44-in. by 10-in., double-arm, Oneida split-steel pulley which is driven by an engine. The mounting of the driving end of this main shaft, Fig. 4, shows the application of a wall bracket and an SKF ball-bearing, pillow block for supporting the driving end of the shafting. Here the wall brackets are mounted on 3-in. by 10-in. planks set upright against the wall. Another pair of planks is also placed on the other side of the wall. These are bolted together with steel plates used under bolt heads and nuts, which gives sufficient bearing surface so that the bolts will not loosen during operation, as might be the case if the bolt heads were placed directly against the wood. The planking is also bolted through the wall both above and below the wall brackets. This ties the whole wall up solid and gives practically the whole area of the side of the planks as a bearing surface.

When fastening lineshafts to the ceilings of reinforced-concrete-constructed buildings, a very common method is to use special steel inserts which are cast in the concrete. However, in many cases industrial plant engineers do not know, when the building is built, exactly where the lineshaft is to extend, or find it necessary to make changes after the building is up. This necessitates then that the hangers be fastened

(*Please turn to page 554*)



Fig. 7 — Substantially-built, mill construction buildings are generally the most satisfactory for erecting lineshafts.

This is one of three shafts recently erected at the plant of the Wolff Mfg. Co., Chicago, Ill. The drop hangers are spaced on 8-ft. centers, except at the driving pulley, where the hangers are on 4-ft. centers. The footings or cleats for supporting the hangers are fastened to the joists with two lagscrews at each end. This is a 2 15/16-in. shaft, 100 ft. long. The motor is so placed that the driving pulley is approximately in the center of the shaft.

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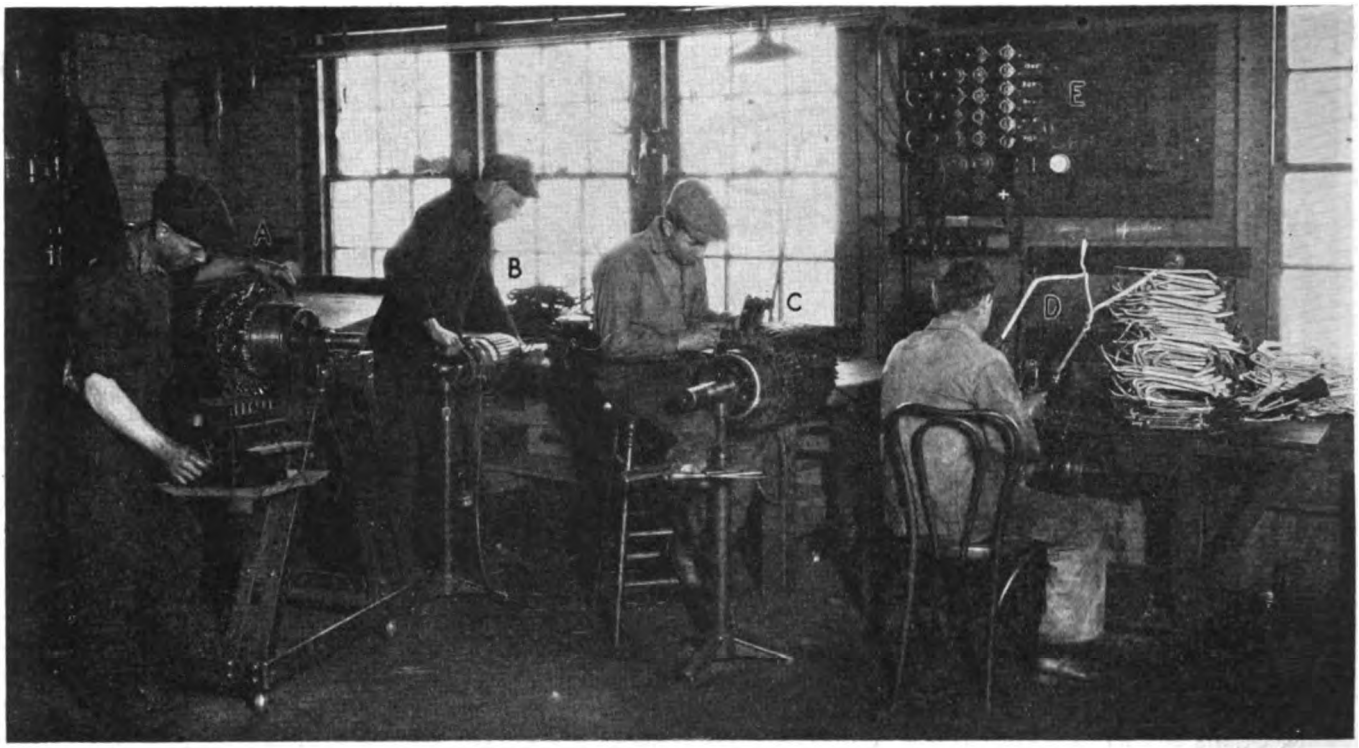


Fig. 1—This is the rewinding section of the repair shop.
The man at *A* at the left is testing an armature with its top leads raised with a megohmer for insulation resistance. A final millivoltmeter bar-to-bar test, *B*, is made on all finished armatures. Soldering, *C*, is done with a double-flame torch. The operator, *D*, is taping coils and has at his right a pile of finished coils. The testing board, *E*, consists of parallel and series lamp banks. Some of the lamps are removed here to give a better view of the board.

Details of methods and equipment used in

Rewinding and Repairing Armatures and Motors

which operate under severe service conditions, together with shop tests and records that show the quality of the work

By CHESTER A. WILLIAMS
Electrical Repair Shop, Providence Gas Company, Providence, R. I.

PLANT repair shop practices, methods and equipment are governed largely by the amount of work to be done and the conditions under which the equipment is operating. The large shop can adopt ideal equipment and the best and most economical methods. The small shop is often forced to use what it can design and construct itself. Additions to the equipment, however, are made gradually as the shop feels it can afford them and can convince the management of their economy, desirability and necessity.

The number of repairs necessary and the kind or extent depend to a large extent upon the conditions under which the motors and other equipment operates. The manufacture of gas is a process which continues, with some fluctuations, 24 hr. a day and 365 days a year. A motor, which is operating in evenly-heated and well-ventilated buildings under conditions free from acid or corrosive fumes and conducting dusts, requires entirely different repair practices from one operating under adverse conditions. The manufacture of gas and by-products is a good example of the adverse conditions in which the three worst enemies of electrical equipment are coke dust, ammonia and extremes of temperature. Of the three, coke dust, which contains 87 per cent or more of carbon, is the worst enemy; electrically, by short-circuiting the windings and commutators, and mechanically, by causing serious bearing trouble.

At the plant of the Providence Gas Co. approximately 150 motors of nearly 2,000 hp. total rating are required to operate the equipment. The direct-current motors range from 1 to 75 hp. and the alternating-current motors from 1 to 300 hp. The majority of the motors range from 10 to 20 hp. Direct current is generated at 250 volts. The alternating-current equipment is operated at 440 volts with purchased power.

A considerable number of these motors operate in an atmosphere of coke and coal dust. A few are directly subjected to ammonia fumes, which attack the copper and cause high-resistance contacts and poor commutation.

The crew required for inspection and repair of this equipment is composed of the foreman, one night and one day maintenance men and two helpers, one oiler, one armature winder and helper and a construction man and helper. The night and day maintenance men inspect the equipment and do any necessary troubleshooting. The two helpers work on the day shift, either with the day man or on any necessary repairing, overhauling or other miscellaneous work which comes up. The oiler blows out the equipment

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Do Following work on this piece:

Date 4/1/25 Chg. Acct. # 147 M.O.#

Name of piece Armatures

Symbol No. or (S.K. 70 (W)
Where Located (Coke crusher

Winding - (new) - repair

Commutator - (repair) - (turn)

Shaft - (build up) - (turn) - (grind)
- polish

Keyway - (recut) - refinish
(fit key)

Nuts - new - fit

Pinion or pulley - new - (fit)

(Fit bearings)

Checked by .....

Fig. 2—This work tag goes with all armatures sent to the machine shop.

with compressed air and watches for any indications of possible bearing trouble, in addition to his oiling routine. The duties of the armature winder and the construction man, and their helpers, are obvious.

Equipment and Methods Used in Repairing Armatures

The equipment in the electrical repair shop includes a 36-in. by 8-ft. banding lathe, a 10-in. speed lathe, a 50-in. insulation cutter, a Segur bar loop winder, a wire loop winder, a taping machine, a 16-in. by 55-in. spreader, a two-wheel floor grinder, a 2-ton Peerless hoist and a 3½-lb. electric soldering iron. Figs. 1, 4 and 9 show different parts of this workshop and some of the work done. Commutator turning and all machine work are performed in the machine shop, a portion of which, containing several of the larger machine tools, is shown in Fig. 6.

Because most of our trouble with a motor is in the armature, we keep a large number of spare armatures instead of spare motors. Altogether there are a total of 61 spare armatures with at least one and in some cases two spares for every important piece of apparatus. This minimizes loss of production and allows more time for proper repairs.

Every spare armature is equipped with properly fitted bearings, a pinion or pulley and a key; special attention is given to the latter. Keys are machined to within 0.001 or 0.002 in., are fitted by hand filing until an even bearing is secured and are required to be driven in at least half way during the fitting before they are O.K.'d. This is a large factor in eliminating lost time and prevents unnecessary interruption of production when making a change.

Practically all bearings and pinions are made in the machine shop and the machinists do all the fitting to the journals. Spare armatures are stored on racks about 3 ft. from the floor, with a small exhaust steam coil under each rack. Steam is kept on during both summer and winter, so that the armatures are kept perfectly dry and slightly warm.

Armature & Motor Rep'r Data

Date Rep'd 1/1/25 Installed.....

Symbol No. or (R.C. 8 Z
Where Located (

Mfrs. No Gen. Elec.

Trouble Grounded by coke + oil. Insulation under coil ends short

Where Located Rear end

Reference Rewound - new coils - Mica ring installed under coil ends

Rep'd by H.

Test, BtoB. O.K. Ground 50 meg.

Tested by G.G.

Fig. 3—After all work is completed on an armature, it is tested and this record filed.

Almost every type of armature repair is made, either in the *Electrical Department* or in the machine shop. Journals measuring 0.005 in. or more under standard are built up by arc welding and turned down in the machine shop. We do not build new commutators, but those which have carbonized mica are rebuilt and, occasionally, a bar or two is made to replace defective ones, if the commutator is otherwise good.

Approximately 100 armatures were repaired during 1924 and required the following quantity of materials: 243 lb. of magnet wire, 402 rolls of cotton tape, 22 rolls of silk tape, one 50-in. roll of fishpaper, 15 lb. of mica fishpaper, 31 18-in. by 36-in. sheets of segment and molding mica, 55 gal. insulating varnish, two rolls of 36 in. varnished cambric and 15 lb. of 1/16-in. sheet fiber. Also, 641 rolls of friction tape, 103 rolls of splicing compound and 275 lb. of

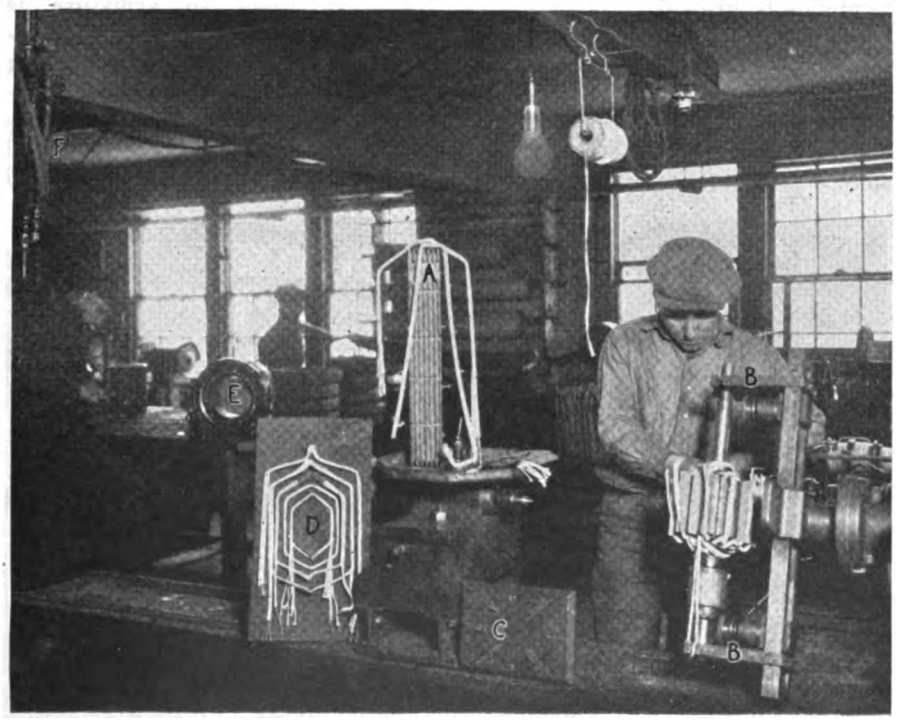


Fig. 4—Another section of the shop for the Electrical Department, and some of the types of work done.

On this special form for winding coils the wire is crossed over at the point marked *A*. A finished and unfinished coil which were made on this form are shown alongside. The attachment, *B*, to the hairpin loop winder is in use winding a 5-hp. armature. The adjustable form, *C*, is used for winding small wire coils. Several of the types of coils which are made in the shop are shown in *D*. The 1-hp. stator, *E*, has just been dipped and baked. Two sets of large field coils are shown on the bench at the right of *E* and the insulation rack and cutter are over by the wall and window. The air and gas connections, *F*, for the soldering torch are hung up when not in use.

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solder were used, either in the shop or around the plant.

The small amount of magnet wire used is due to the fact that we use old coils whenever possible for the larger sizes of armatures after they have been reinsulated. Also, several sets of coils were purchased about the first of the year.

The methods used in armature winding have been given special consideration, because at one time the life of certain newly-wound armatures used in the coke department was from two to three months. After considerable study of the problem we decided on the following method of procedure which is giving good results. Armatures with grounded or shorted coils are seldom repaired unless the repair be made without raising the coils. If the service is not severe and the winding seems good except for one or two coils, the damaged ones are cut in the loop, disconnected and jumpers put on. This is not only a quick and inexpensive repair but our records have shown that a smaller percentage are returned than when new coils are inserted.

If it is necessary to rewind the armature, the old coils are removed as carefully as possible and those showing a good test are reinsulated during spare time. The core is given a good cleaning and reinsulated. The commutator is required to stand a 50-megohm test between bars and to ground before being passed. This sometimes requires two days' time, but we consider that the new insulation makes it as good as a new one and our records of results show this to be good practice.

The usual string band is put on and the commutator is sealed at both ends by a small amount of Bakelite cement rubbed on with the finger in such manner as to give a thin coating over the string band and ends of bars. Too much Bakelite in any one place will bubble out during the baking and makes a poor job. Coils are baked to exclude moisture and

MOTOR CHECK CARD

Make of Motor.....Type.....Serial.....

Location.....Date.....

Are coils thoroughly insulated from ground....
Has polarity of coils been checked.....
Are coils a snug fit.....
Are field poles drawn tightly to frame.....
Are brush holders and studs tight.....
Did you get a 50 MEG. test between connected coils and ground.....
Are all coil connections and leads equipped with connectors.....
Are all leads through frame properly bushed with fiber.....
Does armature rotate freely.....
Has it about 1/8-in. end play.....
Are the bearing dowels in.....
Have the brushes been fitted to the commutator.....
Are they evenly spaced.....
Is the tension alike on all brushes.....
Have you checked the clearance between armature and poles.....
Are oil rings turning freely.....
Are the oil retainers and covers in place.....
Are there any screws or bolts missing.....

REMARKS.....

.....

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.....

.....

Signed.....

Fig. 5—The repairman must fill out this record, which is filed, on all overhauled motors before they are O.K.'d.

the winding is done in the usual manner after a three-cornered file has been run across each slot to eliminate any burrs.

Fishpaper is used for slot insulation. Bottom leads are placed as the winding progresses. When the coils are in and before the top leads are put down, another insulation resistance test, using a megger, or megohmer, is then given both between bars and to ground at one operation, by connecting one of the terminals to ground.

In passing from bar-to-bar for this test, if one of the coils or bars should be grounded it will show up through the third wire. On this test also the armature is required to show a resistance of 50 megohms.

The armature is finished in the usual manner. The soldering is done with a small gas-and-compressed air torch. Rosin and alcohol is the only flux used. Numerous tests have been made but no bad results have been noted to date from the use of the torch. A 5- to 10-hp. armature can be soldered in from 20 to 30 min. and we seldom have trouble from high-resistance connections. The completed winding is dipped in Sterling extra-insulating varnish, baked, and sent to the machine shop with the work tag, Fig. 2. When completed, a final bar-to-bar test is made with the millivoltmeter and the armature tested to ground. If it is O.K., the armature and motor repair data card, Fig. 3, is filled out and filed. This card has been an important factor in solving some of our trouble.

All armatures of the same make and type are stamped *Z*, *Y*, *X*, and so on, for purposes of identification. As an example of the value of this card, if two or more armatures, working under similar conditions, are returned for grounds at the rear end, extra precautions are taken to remedy this, as shown. The card also shows how long the armature has been in service, whether or not special precautions were taken, who repaired and tested it, and what the test showed. Our practice of making rigid tests has grown out of the use of this card and two brands of insulating varnish have been discontinued because of the poor results as shown by this record.

Usually when an armature is found with low bearings, it is replaced instead of merely changing the sleeves. As stated before, bearings are fitted to each spare armature. The next step is to raise all top leads and give a bar-to-bar and

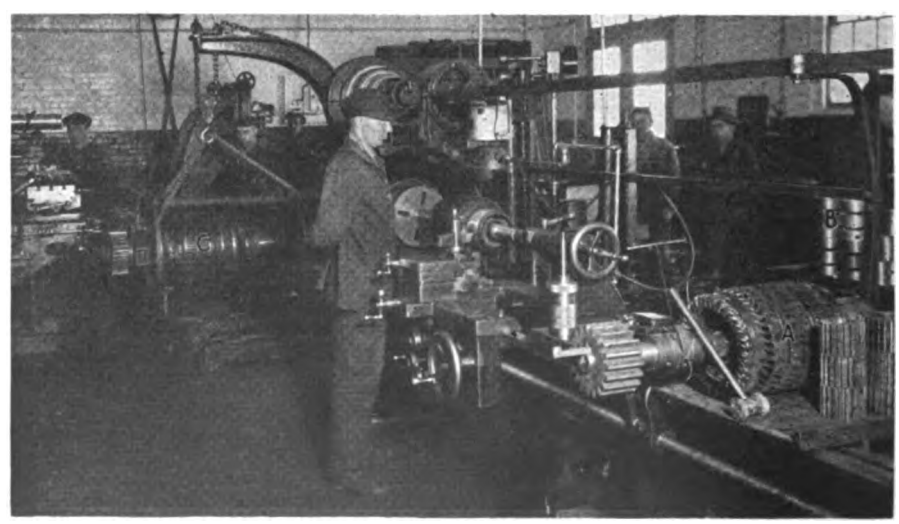


Fig. 6—Mechanical repairs to electrical equipment are made in the Machine Shop.

Spare armatures, of which there is at least one for every important drive, are fitted with pinions or pulleys, keys and bearings in the machine shop before storing away. This makes a complete unit which can be installed quickly. Shafts which are worn down are built up by arc welding. The 20-hp. armature at *A* is fitted with its bearings, pinion and key, ready for storage. Only lead hammers are used for driving pinions. Several pinions are piled at the right of *A* and a number of bearings at *B*. At *C* is a 100-hp. armature fitted with spare endplates, bearings and pinion.

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ground test with the megger, as described above, as we find that the millivoltmeter is unreliable on old work because it does not show up leaks due to carbonized mica and carbon dust. Old armatures which show a resistance of one megohm are passed if there is not much variation between bars and to ground.

Two-pole motor armatures are wound in the banding lathe, as shown in Fig. 4, by using a shop-made attachment to the coil winder. This procedure is much quicker, but requires careful insulation between coils at both front and rear. The usual winding time is 5 to 6 hr., including the time required to place the sleeving which is used on bottom leads only. We seldom try to repair coils in this type of armature, but occasionally cut them out and insert jumpers.

Our practice is to overhaul a complete unit at such time as a piece of equipment is shut down for any reason long enough for us to do so. We strip and clean the motor thoroughly, give it a coat of insulating paint and put in new coils. The old coils are later reinsulated, dipped in Sterling varnish, baked and put back in stock.

A large part of the success of our repair work is due, we believe, to the thoroughness of our tests and the records we keep on all repaired equipment. For example, after overhauling the motor, the repairman is required to check each item on the card, Fig. 5, before it is O.K.'d. When he knows that this information is put down in black and white and kept on file, he is sure that the test and record are right.

When the testing, after overhauling, is completed the motor is oiled and given a short running test for direction of rotation, speed, amperes at no load and brush setting. It may be interesting to note that in connection with the motor repair work, the following coils were replaced for failures during the year:

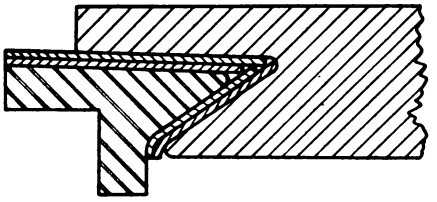


Fig. 7—This cross-section view indicates how the mica rings are formed for the cones of the commutator.

41 main field coils, 25 commutating coils, 27 resistor coils and 12 holding coils.

How Commutator Troubles and Repairs Are Handled

The repair work on commutators is confined mostly to carbonized mica segments and the outer cones which are damaged by shorts just under the edge of the bars. This trouble is being rapidly eliminated by the use of Bakelite cement. Most of the burned-out cones are traced to a combination of oil and coke dust which makes an excellent conductor. Mica segments are made by inserting a piece of segment mica between the two bars and holding them in a smooth, swivel-jaw vise. A fine-tooth hacksaw blade is used for cutting off the excess mica.

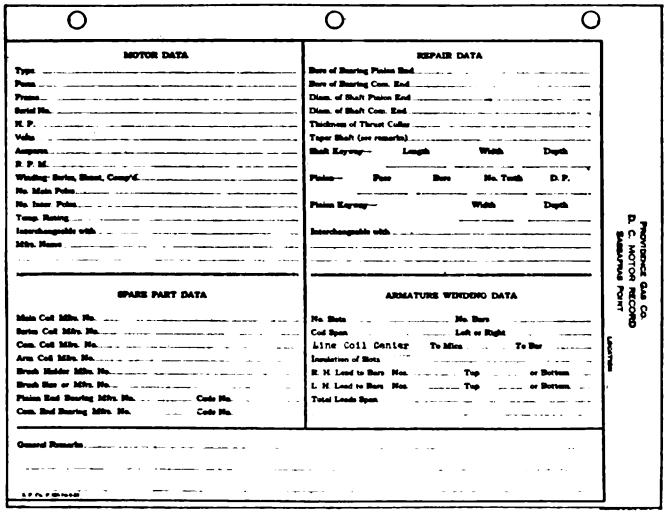
Cones are made from molding mica in the following manner: After laying out the pattern two pieces each for the inside and the outside rings are cut. Each piece is drawn through a flame to make it pliable before forming. Next, a piece for an outside mica ring is placed, while hot, around the iron cone and held until cool enough to retain its shape. It is then marked and cut 3/8-in. too long and the lap is halved in. The second mica is formed in the same way over the first and the inside rings are formed in similar fashion. The cross-section of one side is shown somewhat exaggerated in Fig. 7, which indicates how the rings are assembled after treating with varnish except for the parts coming in contact with the commutator. This and the iron cone are well heated and gradually drawn up tight. We have had splendid satisfaction from this method and it requires only about 45 min. to make the cones. Before discarding the pattern, a template is made of tin and the type of armature is stamped upon it. This saves considerable time on future work.

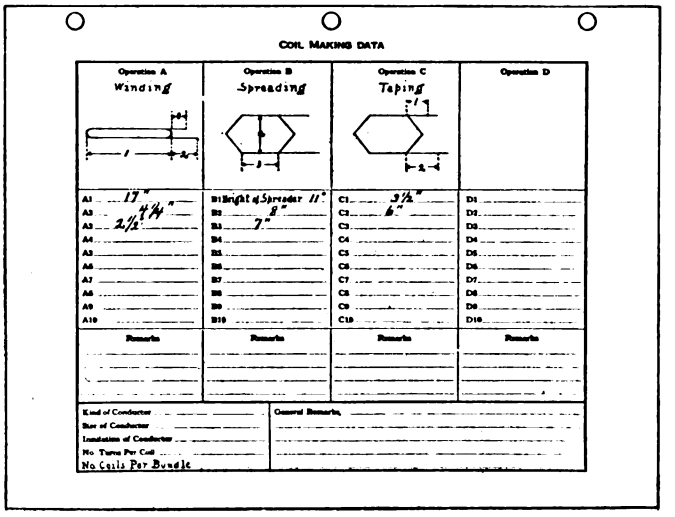
Commutators are undercut 1/64 in. if the motor is located in a clean place. Experience has indicated that it is bad practice to undercut the commutators on motors driving conveyors or crushers, and on boiler room motors. Acme commutator stones are used on these commutators as soon as any trouble occurs.

Armature Coil Making, Dipping and Baking Practice

When an armature is stripped for the first time, the winding data are recorded on the form, Figs. 8*A* and 8*B*, which is filed in a loose leaf binder. This reduces the set-up cost very materially, as it takes but a moment to set the winder and spreader to the scale as recorded on the sheet. Other time-saving features can be seen by a study of the

Figs. 8 A and 8 B—When an armature is stripped for the first time, the winding data are recorded on this loose-leaf sheet.





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data which are recorded on this card.

Coils made on the hairpin loop winder are made and spread in the usual manner. We do not attempt to tape in cells as we have little trouble with coils breaking down in the slots. Fishpaper of sufficient thickness is used in the slots so that coils may fit snugly; the insulating varnish seals and makes them trouble-proof. Two sets of coils are always made at one time as this reduces the cost per coil of setting up the equipment.

Certain types of wire wound coils can be made much quicker in special forms. One such form, with a coil made on it, is shown at *A*, Fig. 4, which shows clearly how the form is made. The advantage in the use of the form lies in the reduction of the number of operations. This particular form is used to make 4-parallel, three coils per bundle, open coils from No. 13 wire and having rectangular ends when spread. The slots are the right width for three wires and are four wires deep; the coils are wound with three wires in hand. When one slot is filled (four deep), the winding is crossed over to the second slot (at *A*, Fig. 4) with only a momentary stop and the operation is continued until the six slots are full. After tying, the coils are sawed through with a fine-tooth hacksaw and then removed, dipped and baked before further operations are performed on them.

Our method of dipping and baking is somewhat unusual and would hardly be suitable for a large repair shop. The armature is put in the banding lathe and by the use of a space heater containing six Cutler-Hammer, 2-amp. units, all moisture is driven out. When dry, the heater is replaced by a pan blocked up as high as the shaft will permit and of a length sufficient to include the commutator, which is covered with a layer of paper and friction tape. The pan is filled as full as possible with varnish, and the armature turned slowly by hand, or a fraction of a turn is given at intervals, until every part of the winding is sure to be covered. The pan is then lowered to the lathe bed. The armature is allowed to drain more or less according to the thickness of coating desired. The lathe is then operated slowly to prevent the varnish running and the pan is replaced by the heater. Two pieces of sheet metal are placed, one on each side of the armature, to help confine the heat. The varnish does not drop on to the heater because of the slow rotation of the armature in the lathe.

On armatures for motors up to 20 hp. a temperature of approximately 200 deg. F. is obtained, which requires a baking time of from 10 to 20 hr. according to their size. Larger armatures do not attain this heat and require longer baking. They are usually allowed to bake over night and the night maintenance man inspects them occasionally. This method has its disadvantages but the quality of the work is good.

The advantages of this method are: It has a low first cost; a minimum amount of varnish is required in stock as 12 gal. is sufficient for a 100-hp. armature; the necessary equipment takes up little room when in or out of use; a heavier coat of varnish can be applied as the rotation prevents draining; it makes an even and good-looking job, as the varnish does not sag; the necessary equipment can be made in the shop by almost any good plant mechanic.

Its disadvantages are: Excessive labor cost, as it requires about 2½ hr. per piece except on armatures of 5 hp. and less; the pans must be set up, the varnish has to be taken out and returned to the can each time, the pans must be cleaned out and so on; the cost of heat is excessive, especially if power is purchased; the lathe cannot be used for other purposes while baking. It is our intention to replace this outfit shortly with a dipping tank, an oven and a trolley.

The cost of our armature winding is not excessive, however, as is shown by the data on jobs of three representative sizes. These figures do not include the overhead:

Gen. Elec., 5-hp., 12-pole, Type RD.. 26A, Lathe Wound

Labor cost, including handling	$10.18
Varnish, insulating material, etc.	3.25
8 lb. No. 16 c.e. wire	4.80
Total cost	$18.23

Westinghouse, 10-hp., Type SK 70

Labor cost, making coils	$ 5.67
Labor cost, winding and handling	17.90
30 lb. copper at 60c	18.00
Insulating material, bands and solder—estimated	3.64
Total cost	$45.21

Elwell-Parker, 100-hp., Special Multipolar Crane Motor

Labor stripping, reinsulating coils, rewinding, turning and handling	$52.00
Insulating material, solder and bands	16.80
Total cost	$68.80

Regardless of where the work is done or what the method is, results are what count. My opinion is that

(*Please turn to page 531*)

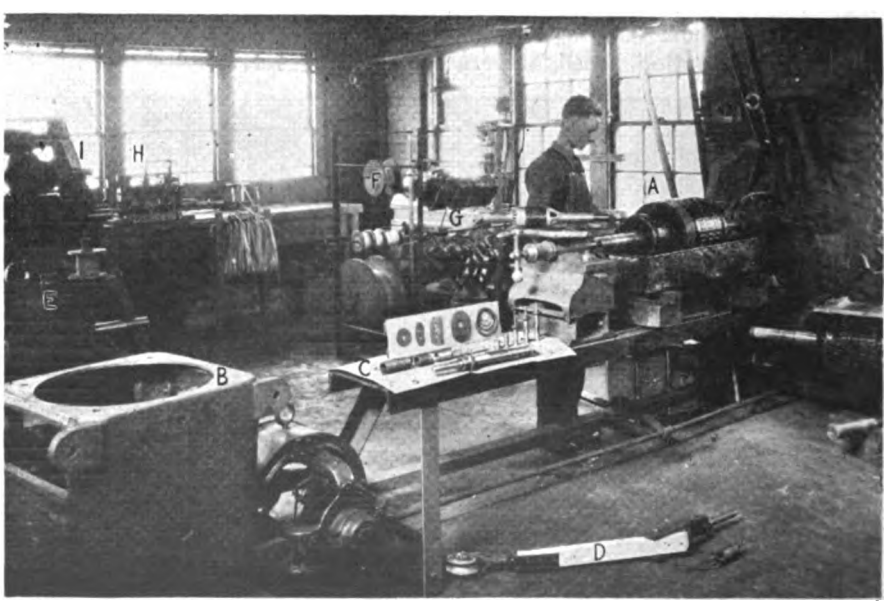


Fig. 9—All dipping, baking, armature coil winding and banding are done on this lathe.

This keeps the lathe busy nearly 24 hr. a day. How a 40-hp. crane motor armature is dipped is shown at *A*. The bed and legs of this lathe were made in the Machine Shop from a large channel and angle iron. The head and tailstock were taken from an old lathe and blocked up on short sections of I-beams. This lathe is rugged and satisfactory. One of the jobs in the shop when this picture was taken was a 60-hp. G. E. crane motor, the frame of which is shown at *B*. *C* shows samples of spare parts which were made in the Machine Shop. *D* is a telpher trolley pole partly assembled. *E* shows two coil frames and a finished coil. *F* is a wire-reel rack, and a set of field coils which have just been dipped and baked, are shown in front of it. Magnet coils are wound on the speed lathe, *G*, in front of the window. *H* is an armature coil spreader, with a set of coils, and *I* is a portable armature rack.

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Summary of the

Recent Changes Made in National Electrical Code

that affect the rules governing installation and protection of equipment, together with revisions which make some rules more easily understood

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer

THE 1925 EDITION of the National Electrical Code, published by the National Board of Fire Underwriters, has been approved as an American Standard by the American Engineering Standards Committee. The biennial revision of the Code was performed by the National Fire Protection Association as the sponsor organization through a sectional committee having 39 organizations represented in its membership, including several Federal, state and municipal bodies, in addition to the various technical, industrial and commercial associations concerned. In this article the more important changes which will appear in the 1925 Code and are of interest to industrial plant men, are enumerated and discussed in detail.

ALTHOUGH no radical changes have been made in the new edition of the Code there are many variations from the 1923 Code. Some of these variations are the result of thorough editorial revisions in the way of improvements in wording or rearrangement of rules to make them clearer, with no change in the intent or requirements of the rules. In consequence the 1925 Code will be more nearly free from errors and conflicting or ambiguous statements. Other revisions are, however, quite important; those which are of particular interest to industrial plant men will be discussed briefly in this article.

In Section 402, a new paragraph c has been added which reads:

When a service from overhead supply wires to a building is carried underground, the portion of the wires underground and running up the pole to a point at least 8 ft. above the ground shall be lead-covered and suitably protected from mechanical injury.

A new paragraph, e, has also been added to Section 404, covering the service entrance protection of systems operating at more than 600 volts. The new rule states clearly the requirements and optional provisions for the service entrance equipment.

Changes in Section 405 include a new paragraph, a, to the effect that in that section the word switch is to be construed as including a circuit breaker that may be manually operated.

Rule 405 b in the 1923 edition has been expanded into two paragraphs, c and d, in the 1925 Code. The new Rule 405 d 2 reads:

Where the switch and fuses are mounted in an approved cabinet having no live parts or wiring exposed and capable of being sealed or locked, the switch blade may be omitted in any grounded conductor if other means is provided within the cabinet for disconnecting such conductor.

Another new paragraph, j, reads:

An automatic overload circuit breaker may be used in place of both service switch and fuse and when not subject to competent supervision shall be of a type specially approved for service conditions.

New Rule 405 l provides that for groups of buildings fed from one service or generating plant, a service switch shall not be required in the building served if the feed to that building is switched at the center of distribution.

Under Section 504, a new paragraph, j, covers combination metal raceways which are designed to afford a convenient means of providing the necessary outlets for both light and signal wires in office and similar buildings.

Under Section 603, Flexible Cords, there is an important exception to paragraph c which reads:

Exceptions: For Types PO, P and PWP with conductors of No. 18 gauge, the rubber insulation may be 1/64 in. in thickness. When Type PO cord has 1/64-in. insulation its use shall be confined to portable lamp fixtures.

This change will permit the use of armored reinforced cord, ordinary reinforced cord and weatherproof reinforced cord with a minimum insulation of 1/64 in. of rubber on each conductor, instead of the 1/32-in. rubber insulation required by the old Code, and thus allow cords of considerably smaller dimensions than were required by the previous rules, to be used.

A slight change has been made in Rule 701 m covering the use of outlet boxes or plates. This rule previously required the use of such outlet boxes or plates on conduit, metal raceways, armored cable and "concealed work." The words "knob-and-tube work" have been substituted for "concealed work," which expression has gone out of use in the Code. The new rule thus clears up the question of the requirement of outlet boxes on knob-and-tube work.

A new rule, 802 a, limits the use of link fuses to capacities of more than 300 amp. In other words, link fuses in capacities up to 300 amp. are prohibited, which is in line with the trend of development in fuses.

A change in Section 805 e provides that all cutout bases, circuit breakers and fused switches, except when located in approved rooms or fireproof electric closets, shall be enclosed in approved cabinets or cutout boxes, or be so designed, protected, or located that live parts will not be exposed to accidental contact.

In the rules covering general fuse protection, there appears a new Rule, 805 p, which reads:

A fuse or trip coil shall be placed in every ungrounded wire of all grounded circuits, except as provided for branch circuits in Section 807 of this code.

This new rule clears up a subject which has been the cause of much discussion. It is quite common on three-phase circuits to ground the neutral point of one transformer in order to obtain the lowest potential to ground. The old rule of the Code was sometimes interpreted to permit trip coils in two wires only, leaving one wire without protection against grounding, which was not the intent of the Code rule. The new rule will tend to clear up any misunderstanding on this point.

Several changes have been made in the different paragraphs of Section 807, Fuses for Lighting and

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Appliance Branch Circuits. For example, the terms, "Branch Circuit," "Outlet," and "Appliances" have been clearly defined in paragraph a, as follows:

"Branch Circuit"—Branch circuit is that portion of a wiring system extending beyond the final fuse or fuses protecting it. For particular applications to motor branch circuits, reference should be made to Section 808.

"Outlet"—An outlet is that fixed point on a branch circuit at which current is taken to supply fixtures and appliances. An outlet having a fixture with more than one socket attached shall be considered as one outlet. An outlet having a multiple receptacle installed therein shall be considered as one outlet.

"Appliances"—Appliances are current-consuming devices for domestic or general commercial use, such as heating, cooking and small motor-operated devices, etc., suitable for use on 15-amp. branch circuits.

Section 807 b has been revised to read :

All ungrounded wires of a branch circuit shall be protected by fuses or circuit breakers. When the grounded conductor is identified and properly connected, branch circuits shall be protected by fuses in the ungrounded wires only. In locations where the conditions of grounding or the liability of the reversal of connections warrant, the inspection department may require, on systems having a grounded neutral or having one side grounded, that both wires of two-wire branch circuits shall be fused, even though the grounded conductor is identified, and properly connected.

It will be noted that when the grounded conductor is identified and properly connected, the neutral fuse *must* be omitted, although inspection departments are given the authority to require double-pole fusing when conditions warrant it.

A number of changes have been made in Section 808, Protection of Motor Circuits; thus paragraph a now reads:

The conductors of circuits supplying current to a single motor shall have a carrying capacity, according to Section 610 of this Code, which is not less than 110 per cent of the nameplate current rating of the motor.

It will be noted that the qualifying clause, "the actual size to be determined by the rating of the fuses or the setting of the circuit breaker or overload relay protecting them," which appeared in the 1923 Code, has been omitted in the 1925 edition.

Rule 808 b now reads:

Each ungrounded conductor of a circuit supplying current to motors shall be protected by a fuse or by a circuit breaker, except the conductors supplying current to a single motor and which are suitably protected from mechanical injury shall be considered as sufficiently protected by the fuses or circuit breakers next back on the line, if the carrying capacity of these conductors is at least one-third of that of the wires to which they are connected and their length to the motor protective devices does not exceed 25 ft. A fuse or circuit breaker shall not be placed in any permanently grounded conductor supplying current to motors, except that a circuit breaker with one pole in each conductor may be used provided the breaker is so designed that the pole in the grounded conductor cannot be opened without opening simultaneously all of the conductors of the circuit.

This is interesting and important in that under certain conditions it permits the size of wire required for a single motor to be smaller than was allowed in the previous edition of the Code. It comes about as a result of the rule allowing the wire to be overfused 300 per cent. Back of it is the fact that although the starting current of an alternating-current motor may exceed the allowable carrying capacity of the wire, the length of time that this heavy current flows is so short that the heating effect may be neglected. Furthermore, the length of the motor circuit is limited to 25 ft.

Rule 808 e has been revised to read:

The wires in that portion of a motor circuit between a motor running protective device which is shunted or cut out during the starting period and its motor shall be considered as sufficiently protected during the starting period if there is a fuse or circuit breaker back on the line which is rated or set at not more than 500 per cent of the nameplate rating of the motor.

The 1923 Code required that the rating of the fuse or the setting of the circuit breaker should be not over 300 per cent of the motor nameplate current rating.

In Section 811, paragraph a has been revised to permit heating appliances each of 1,320 watts or less to be grouped on a special circuit protected by fuses of not more than 15-amp. rating. Appliances of more than 1,320 watts total capacity must be supplied by a separate branch circuit.

Paragraph b has been amended to provide that individual heating elements of electric heating appliances shall be fused if they are rated at more than 30 amp.

Several revisions have been made in Section 901, Grounding. For example, in paragraph a, the word "objectionable" has been substituted for the word "appreciable." Also, directions for eliminating the objectionable flow of current, in certain cases, have been added, as follows: Where an objectionable flow of current over a grounding conductor occurs due to the use of multiple grounds, one or more of such grounds shall be abandoned or their locations shall be changed.

Paragraph c of Section 901 has been changed to require the use of ground pipe not less than ¾ in. *internal* diameter. The 1923 Code called for pipe not less than ¾ in. external diameter. This paragraph further provides that driven pipe or rods shall be of only one piece when of less than standard commercial length and shall be driven to a depth of at least 8 ft., regardless of the size or number of rods or pipes used.

Paragraph d of Section 902 has also been revised to cover more thoroughly the various types of grounding, especially three-phase systems with one phase grounded at the transformer and at the neutral point. This paragraph now reads:

On single-phase alternating-current systems the ground shall be made at each service on the line side of the service switch before the service is connected to the line. On multiphase alternating-current systems the ground shall be made as described for single-phase systems if the grounded conductor of the multiphase supply system is brought to the premises for rendering service. By permission of the inspection department the grounding connection for either single-phase or multiphase systems may be made on or near the transformer or transformers, or by connection to a system ground wire.

In Section 905, Grounding Conductors, paragraph a has been revised to permit the use of grounding conductors made of metals other than copper, which will not corrode excessively under the existing conditions. Heretofore the Code has required that copper must be used.

Rule 905 c has been changed to read as follows, the additions to the 1923 Code rule being shown in italics:

The insulation and installation of the grounding wire for circuits, when not protected by metallic piping, shall comply with all requirements of this code applying to wires of the voltage of the circuit to which the grounding wire is attached. *When a circuit grounding wire is installed in metallic piping and is bonded to it at both ends, a bare copper conductor may be used.*

The additions shown in italics have also been made to paragraph 905 d: *Ground clamps* and all grounding wires *which are smaller than No. 4 in size* shall be protected from *ordinary* mechanical injury *by being placed where they are not liable to be damaged or by being enclosed in metal, wood or equivalent protective covering.*

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As revised, paragraph 905 g now reads:

The grounding conductor for a direct-current system shall have a current capacity not less than that of the largest feeder of the same system leaving the station. In no case shall the grounding conductor be smaller than No. 8.

Paragraph 905 j has been amplified and the size of the grounding pipe specified as shown by the following table:

Capacity of Nearest Cutout Protecting Conductors in Conduit, Armored Cable, Metal Raceway, or Equipment	Size of Copper Wire Grounding Conductor	Size of Grounding Pipe
0 to 100 amperes	No. 10	½ in.
101 to 200 amperes	No. 6	½ in.
201 to 500 amperes	No. 4	¾ in.
Over 500 amperes	No. 2	1 in.

Paragraph m of Section 905 in the 1923 Code has been omitted.

Under Section 1302 a new paragraph, g, has been added which reads:

On switchboards where instruments, meters, or relays operate with windings or working parts, at a potential of 150 volts or above to ground, the cases and other exposed bare metal parts of these devices insulated from the current-carrying parts shall be grounded unless isolated by elevation or protected by suitable insulating barriers or guards or where inaccessible to other than qualified persons, in which case grounding is required only when the voltage exceeds 750. The grounding conductor shall be not less than No. 12. Where instruments, meters or relays are operated from current or potential instrument transformers, the cases and other exposed bare metal parts which are insulated from the current-carrying parts shall be grounded. The grounding conductor shall be not less than No. 12. If exposed to higher voltages through transformer windings or otherwise, secondary circuits of current and potential transformers of less than 750 volts shall be isolated or grounded unless placed in grounded conduit or other suitable duct, or identified and guarded as required for conductors of the highest voltage to which they are exposed. When a grounding conductor is used it shall be not smaller than the conductor of the secondary circuit.

Section 1403, Installation of Fixtures, has been amended to provide for grounding of fixtures. In part this section now reads:

a. Straight electric fixtures shall be grounded except as described in 1 and 2 below.

1. Fixtures mounted on metal ceilings or side walls, or on walls or ceilings containing metal lathing, shall be grounded or shall be insulated from their supports by approved insulating joints or by approved insulating fixture supports, and canopy insulators shall be used.

2. Fixtures in open wiring, knob-and-tube work or wooden raceways and not on metal ceilings or side walls nor on plaster walls or ceilings containing metal lathing need be neither grounded nor insulated.

b. Fixtures shall be considered as grounded when mechanically connected in a permanent and effective manner to metal conduit, armored cable or metal raceway systems, or to a separate grounding wire not smaller than No. 14, or to gas piping which is grounded in the manner specified in Article 9 of this code.

In the 1923 Code grounding of fixtures was optional.

A change in Section 1404 a provides that switch sockets shall be so constructed that the switching mechanism interrupts the electrical connection to the center contact, and shall not interrupt the connection to the screw shell unless the connection to the center contact is simultaneously interrupted. This requirement will not become effective until September 1, 1926.

Several changes have been made in Section 5003, Wiring. For example, in paragraph a the 5,000-volt limit in the 1923 Code for wires installed in or above buildings other than central stations, substations and transformer vaults, has been raised to 7,500 volts. Paragraph b has been revised to require that "Elsewhere than in central stations, substations and generator, transformer, switching and motor rooms, all apparatus and wiring connected to circuits of more than 600 volts shall be completely enclosed by substantial shields or casings," etc.

Paragraph d has likewise been amended and now specifies that elsewhere than in central stations, substations, etc., all wiring of circuits of more than 600 volts shall consist of approved multiple-conductor, grounded metal-sheathed cable inclosed in approved grounded conduit.

Section 5008, Transformers in Furnace Rooms, in the 1923 Code has been made paragraph e of Section 5005 in the 1925 Code and Section 5008 now bears the heading, Static Condensers. The three paragraphs under this section read as follows:

a. Static condensers of the type made up of small units, each of which contains less than three gallons of oil, may be installed in power houses or factory buildings if combustibles are kept well away from them. In rooms containing combustible dust or flying material, condensers shall be inclosed.

If condensers are accessible to other than qualified persons a non-combustible grille or guard around them may be desirable.

b. Condensers which have all units in single tanks filled with oil shall be installed as required for transformers in Section 5005.

c. For transformers used with static condensers, the requirements of section 5005 shall be followed; provided, however, that by permission of the inspection department, oil-filled transformers intended for and used only with static-condenser installations and not subject to lightning disturbances may be installed in rooms of non-combustible construction and occupancy. Such transformers shall be of sufficient capacity to allow for ordinary rises in voltage; they shall be surrounded by concrete curbs not less than 6 inches high which form a basin of sufficient capacity to retain all the oil contained in the transformers; and be protected by an automatic overload circuit breaker (or other protective device and switch) set to operate at a current corresponding to not over 150 per cent of the rated capacity of the condenser.

Repairing Motors and Armatures

(Continued from page 528)

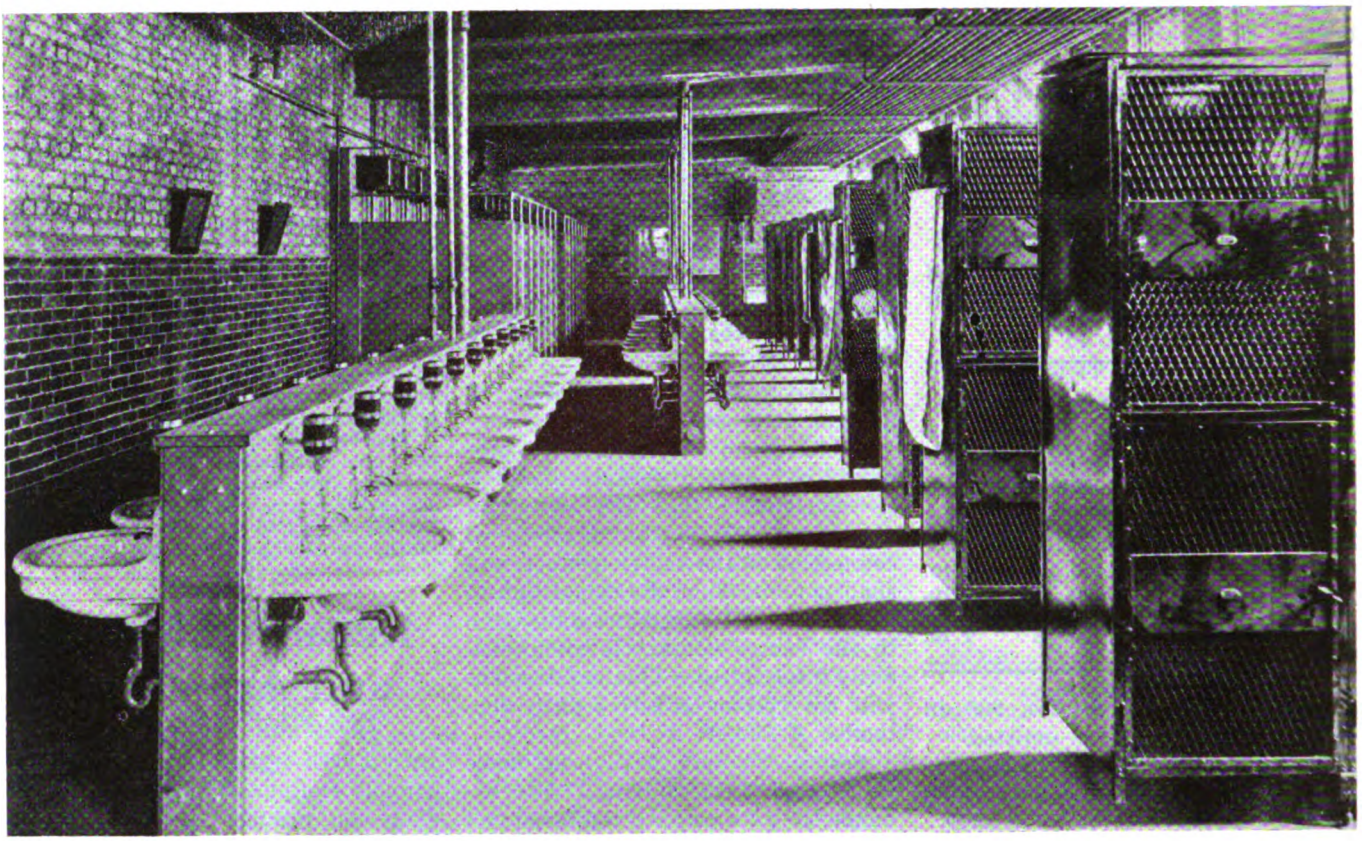
with a well-organized crew and reasonable equipment, the plant repair shop can produce quicker and far better results than can be obtained from outside work. Also, the shop foreman is much better acquainted than a commercial repair shop could be with the particular problems involved, understands the conditions causing them, the requirements under which the motor will operate and is, therefore, better able to meet them.

I have found that it requires considerable thought and study, as well as close attention to details with some kind of system for following up the work, to solve these problems and I doubt if the average commercial repair shop is willing, or could be expected to devote the necessary time in this connection.

Armature removals for electrical trouble at our plant have shown a steady decrease, on an average, for the past 18 months and, while megger tests of armatures on the job in January, 1924, showed an average of about 1 megohm, tests in the same department during January, 1925, showed, with one or two exceptions, infinity.

These pertinent facts may be taken as a fair indication of the results attainable with this method of procedure under extreme operating conditions. These results, and also the low cost of the work, convince us that the records, which we keep on all work, bear an important part in attaining the results.

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This shows a structural slate installation in the washroom of the National Lead Co., Chicago, Ill. The backing, tops and ends of the structure supporting the wash basins are made of slate, as are also the stalls in the back corner of the room.

Things that plant men should know about the

Industrial Applications of Structural Slate

together with money saving ideas in the use of slate, how the various finishes and surfaces are applied, and practical advice on handling and installing it

By FRANK E. GOODING

Associate Editor, Industrial Engineer

SLATE is one of the comparatively few materials that is not affected by moisture and corrosion, and in consequence it finds numerous uses around industrial plants. The use of slate for electrical purposes has been discussed in an article entitled, "Slate as a Switchboard Material," which appeared in the June, 1925, issue of INDUSTRIAL ENGINEER. This use of slate, therefore, will not be covered in this article, except by some comparisons in cases where other industrial uses are the same or differ from electrical uses.

Structural slate is commonly used around industrial plants for shower and toilet stalls, and other sanitary purposes, lavatories, tanks, sinks, vats, laboratory and other special purpose table and bench tops, for trench covers, shelves in packing plants, flagging, for instrument mountings, and, when given special finishes, for wainscoting, window sills, floors, stair treads and other purposes.

Slate is a sedimentary product which was formed from clay under the action of extreme heat and pressure, due to convulsions in the crust of the earth. This original clay was compressed into layers which formed a rock with a natural cleavage which makes it possible to split the slate easily into layers. Slate is found in quarries in Pennsylvania, Vermont, Maine, and some other states, and is quarried in much the same way as other stone. It is removed from the quarry in large blocks which are split along the natural grain into sheets of the required thickness, with sufficient allowance to be finished off as desired.

Slate in general is used for roofing, for miscellaneous purposes, which include its electrical applications, and for blackboards. Slate used for structural purposes is known as mill stock. Such slate must be of a fine, even grain and also must split or cleave smoothly so that it does not require an excessive amount of working to finish the surface. In general, industrial slate comes under two classifications: clear and "ribbon stock." The highest grades of clear slate are used for blackboards and for electrical purposes. For these, as was explained in the previous article, it is necessary that the grain be clear and the slate be free from any impurities which would cause it to be of poor electrical quality or to have natural defects which would not permit its use as a blackboard.

Ribbon stock is so-called because of bands, called ribbons, which run

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through the slate. These are caused by layers of clay containing mineral deposits which appear as bands in the slate. However, ribbons in no way lessen the value of slate for most industrial work, except for mounting electrical equipment, and when the slate will be subjected to acids. The methods of finishing slate will be discussed later in the article.

Physical Characteristics of Structural Slate

One of the particular qualities of slate which accounts for its use as a construction material is that it is practically non-absorptive. Tests have shown that it will absorb less than 0.2 per cent of its weight when immersed in water for 24 hr. This makes slate very useful in wet places, and of particular importance in connection with problems of sanitation. Slate weighs approximately 180 lb. per cubic foot.

Although this material is not generally used for purposes that require high compressive or tensile strength, tests show that it is stronger in both of these respects than are many other building materials. In addition, slate has a high degree of toughness as well as considerable elasticity, which enables it to withstand considerable stress without fracture. This quality is of particular value in construction work.

Another physical characteristic which is of considerable importance in industrial work is that slate has practically no expansion and so can be used for mounting instruments and for purposes which involve its subjection to heat or cold. Also slate is relatively highly resistant to abrasion and so can be used for floors and stair treads.

A factor of particular importance in the use of slate is the desire of manufacturers to standardize on certain sizes for definite purposes, such as for showers, toilet enclosures and so on. In this way they can manufacture slate for storage and not have to wait for special orders before beginning production. A slate manufacturer does not devote all his efforts to one type of product. It is necessary that he manufacture all types of slate products as it is only in that way that he is able to use up the larger share of his production; even then, approximately 75 per cent of the slate quarried is wasted.

It is impossible to quarry slate and stock it to be worked up on order, because after slate is exposed to the air for a short time it hardens and does not split as evenly or easily as when first quarried. Therefore, if users will purchase slabs of standardized size, they can profit by the economies which the manufacturer can make in production. Otherwise the slate has to be quarried, cut and finished to suit each individual requirement.

It is also to the user's advantage to specify and accept ribbon stock whenever it is possible to use it. Ordinarily, even in the best quarries, only about 20 per cent of the slate is clear stock and as it is absolutely essential to use such stock for electrical purposes and for blackboards, its cost is from 25 to 30 per cent more than for ribbon stock. The ribbons have no bearing upon the strength or other physical properties, other than electrical resistance, and as ribbon stock is so much more plentiful than the clear stock it is also cheaper and is, therefore, considered as standard for most purposes, unless clear slate stock is specifically required.

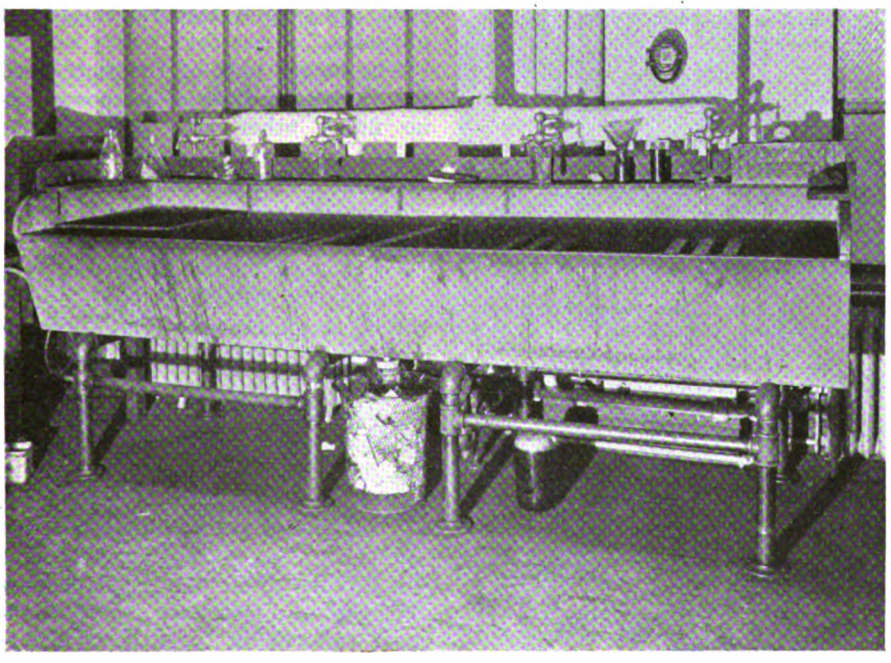
MISCELLANEOUS construction work around the industrial plant calls for the use and installation of various materials with which the plant man may have had little experience. Slate is one of these materials which is widely used, but it is frequently installed when the plant is built. However, the industrial plant man is required to make any changes and additions to the existing installations. Some of the industrial applications of slate, together with a discussion of its origin, the methods of preparing it for use, finishes, grades and suggestions on its use are given in the accompanying article.

Some of the Special Surfaces and Finishes Given to Slate

A knowledge of various commercial finishes and surfaces in which slate may be obtained is useful in that this knowledge will insure proper selection of the surfaces and finishes best adapted to and most economical for the purpose for which the slate is to be used.

The term "sawed edge" indicates that the edge of the slab is left rough, showing the saw marks resulting from cutting the rough slab to the desired size. Sawed edges are confined to slabs up to 6 in. wide, which are particularly adapted to making window sills, edges of wall copings, straight nosing of outside steps, and concealed edges where no finish is required, and similar construction. If a sawed edge is not desired, the next choice of edge finish is the standard sand-rubbed surface.

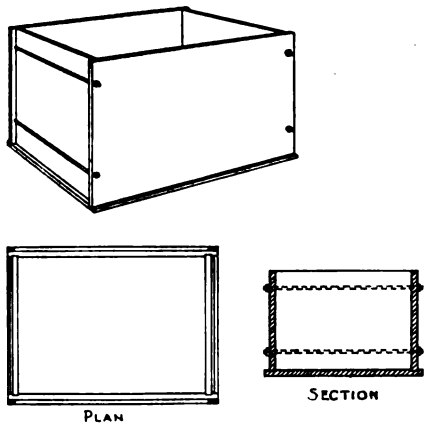
The various surface finishes



This two-compartment acid and washing tank is made of slate.

The floor is also made of slate tile set in concrete. Slate is not affected by most acids, has very little expansion, and is not affected by heat or cold. This makes it a good material to use in the construction of tanks and vats. This is a two-compartment tank; the sides are made of two pieces of slate which join at the division separator slab. Because slate does not expand or contract with changes in temperature, the cement does not work loose in the joints as might otherwise be the case. This illustration was taken of a recent installation in the engraving department of a Milwaukee, Wis., newspaper plant.

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This is one method of constructing slate vats.

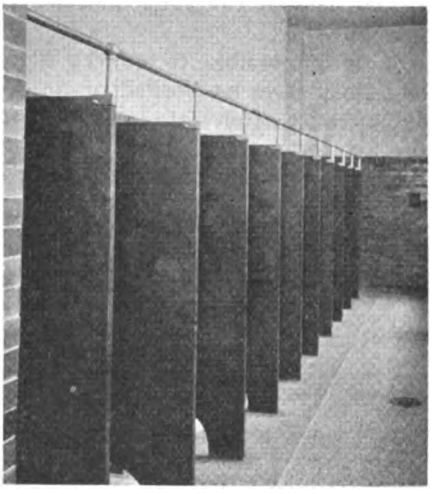
Slate vats used in tanneries or other manufacturing establishments are, if of large capacity, usually constructed as shown in the accompanying drawing. The slabs vary in thickness from 1¼ in. up and the sides and ends are let into the bottom and into the sides. The sides project beyond the ends and long bolts with nuts are used to make a rigid construction. In the construction of smaller slate tanks the bottom and ends are let into the sides and set in waterproof cement.

which may be obtained will be discussed in the order of their manufacture. Split-face surface is the surface left as the result of the first splitting of the slate into the thickness desired and before the slate has gone to the planer. It is a fairly rough surface somewhat similar to a rough grain, although comparatively even, straight, and true in plane. This is the surface generally left on slate roofing and is also used in some cases for architectural effect, and for some outdoor uses of slate. Split-face surfaces should also be specified where a smooth finish is not necessary or where the surface is concealed, as in the back of wainscoting bases, blackboards, the underside of floor slabs and similar places.

The next surface supplied is a "planed" surface, which is obtained by passing the split face of the slab through a planer. The plane marks show faintly and so this finish is used for the back of switchboards and for the underside of stair treads, landings, risers, and wherever absolute uniformity of finish is not essential, but where a straight, smoothly planed surface is required without the roughness of the split face. The standard sand-rubbed finish, which is the next and most common finish used, is obtained by taking the slabs from the planing machine and placing them upon large revolving metal disks where they are rubbed smooth under the action of sand and water. The result is a uniformly smooth, even surface, having a very slight grain or stipple. This is the standard surface supplied on slate for sanitary uses, as well as for wainscots, bases, stairs, flooring, tanks, vats and other purposes.

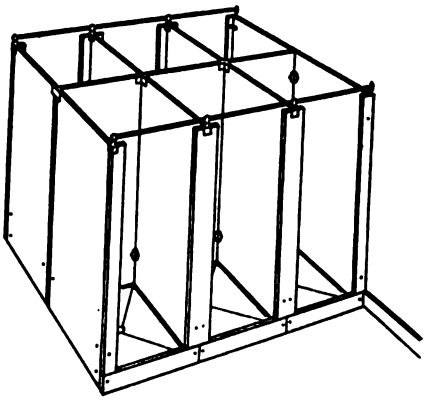
The next and final surface, which may be obtained at an additional cost, is called "honed finish." This can be applied to the surface of slate for any intended use, but in some cases it is not desirable and in others the increase in the cost over the standard sand-rubbed finish would not be justified. If it is desired, however, for any type of installation where the sand-rubbed finish is standard, the honed finish can be furnished, but only when distinctly called for and at an added expense.

The honed finish is finer and smoother than the standard sand-rubbed finish, although the mistake is often made of confusing the two. This finish is produced after the sand rubbing by an additional honing or polishing process. Both finishes produce a similar, perfectly smooth polish, which is the nearest approach to a high gloss that can be given to slate. The honed finish is not a necessary or suitable finish to be given where the slate is to be subjected to the abrasive action which floors, stair treads, and thresholds receive. It is applied only in special instances where a smooth finish is desirable or where it is standard for particular uses, such as for electrical panel boards and other special surfaces.



An economical and effective type of construction for stalls.

Here the lower back corners of the slate partitions are cut away so as to make it easier to clean around them by eliminating the corners, which are so difficult to get at. The legs on which these partition slabs stand are set about an inch into the concrete floor. The tops are held stationary at the upper corner by the pipe rail and fittings, as shown. This installation was made of ribbon stock. The ribbons do not affect the usefulness and serviceability of the material except where it is subjected to acids or is used for electrical purposes. A sand-rubbed finish with an application of oil is the usual finish for such installations as this.



One type of construction for shower stalls.

In this type of installation the slate backs, ends, and partitions are continued to the top of the floor slabs. Other and cheaper constructions are made by leaving off the front stiles or curb at the bottom, or both. The standard curb at the bottom is 6 in. high and the backs, ends, partitions, stiles, and curb are 1 in. thick. The floor slab is 2 in. thick and slopes to a drain in the center of the slab. Frequently lead pans are used under this floor slab. These showers are made in a standard height of 6 ft. 6 in., in two standard widths of 3 ft. and 3 ft. 6 in., respectively, and a standard depth of 3 ft. 6 in.

In addition to the polished or finished surfaces which are ordinarily applied to the slate, there are numerous other finishes which may be applied as ordered. These are generally known as enamel and marbleized finishes. It is possible to give slate a black or white baked enamel finish and also special marbleized finishes which imitate most of the high-quality marbles. These, however, are seldom used for industrial purposes.

The larger part of the slate used for various industrial purposes has no finish other than the surface placed upon it by mechanical processes in the mill, such as the sand-rubbed or honed surfaces. Under ordinary wear and tear of erection, there should be no damage to the surface, due to the strength of the slate. After erection, therefore, no more mechanical work is necessary to finish the edges or faces, such as is often the case with softer and more decorative stone. When an installation of slate is in place it is, however, customary to put some finish on the surface which will not only clean the slate, but will bring out its color and make the slabs more uniform in appearance. One of the most common of these is known as

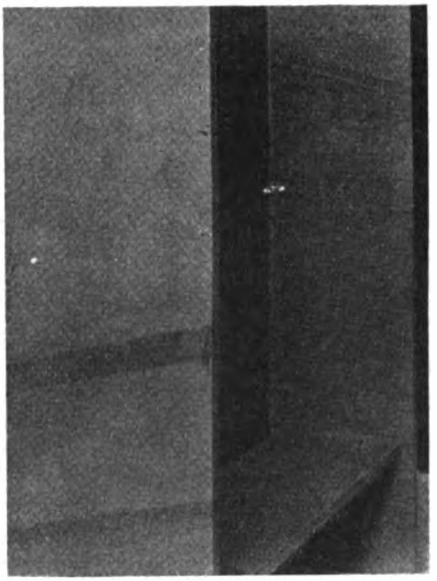
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the oiled finish and is almost universally used, except on enameled or marbleized slate, although other finishes may be applied.

The oil finish is obtained by applying raw linseed oil with a brush or cloth. The oil may be thinned with turpentine if it is desired to apply a lighter coat or it may have lamp black added which makes it black in color. This is the finish specified as standard in nearly all specifications. It does not show ordinary dirt and if at any time it needs freshening, another light application of the oil or oil and lampblack will bring back the finish. This finish is particularly effective on slate switchboards, as was mentioned in the article in the June issue of INDUSTRIAL ENGINEER, and is particularly adapted for use on any installation that is subject to oil splashes.

Oil finish should also be used on toilet or shower stalls and other sanitary installations, for wainscoting and, in general any industrial construction where slate is used for purposes other than its decorative effects. No finish, however, is applied as a rule on stair treads, floors, exterior slate copings, walls, and so on.

The black marine finish gives a moistureproof surface which has the peculiar quality of causing all water on it to evaporate quickly. It is a long-lasting finish of good appearance and is called for frequently in electrical specifications where there is danger of moisture. This finish is produced by applying amylacetate lacquer, colored with black aniline dye, which makes the slate a jet black color. It may be used industrially instead of the oiled finish, but is more generally employed on electrical installations.



The stripes or bands in this slate are due to the "ribbons."

Slate was formed from clay deposits under the influence of heat and pressure. Mineral deposits in the original clay show up as a streak or ribbon in the finished slate. These ribbons do not affect the value of slate for most industrial purposes; clear stock, that is, stock without ribbons, must, however, be used for all electrical installations or where the slate is subjected to acids.

Aside from the oil finish, the most common finishes used on installations of slate in industrial plants are produced with paints or stains. One of the characteristics of slate is that stains and paints adhere to it very firmly. Therefore, it is possible to secure a variety of different effects by the use of stains or wax, which should be applied and rubbed in with a cloth.

If any special tints or colors are desired upon slate stalls, partitions, and so on, lead and oil paints may be used. This painted finish may be applied in the same way as on any metal or stone, although it is recommended that not less than three coats be used and preferably four. The best quality, pure white lead, linseed oil and tint should be used. Experiments have also shown that the Duco lacquers, which are commonly used on automobiles, give very satisfactory results on slate. For most sanitary installations, the oil finish is used on all exposed surfaces. It should be remembered that these finishes are applied after the installation is made, and on a sand-rubbed surface, which is the finish given to the slate by the manufacturer. Unexposed surfaces are commonly left with a planed finish, although sometimes, if set in concrete, are left with a split surface.

When erecting any structural slate it is frequently necessary to drill extra holes. The need of this is minimized if standardized dimensional units are purchased as these are drilled by the manufacturer or, if sufficient planning ahead is done, all necessary holes are drilled according to the specifications given to the manufacturer.

Drilling a hole in slate, however, is not a difficult nor long job, if properly done. If an attempt is made to use a fairly large drill it will usually be difficult to drill straight through. It will invariably sheer off to one side, due to the hard veins in the slate. The surest way to get the hole where it is wanted is to first drill all the way through with a small drill, about ⅛ in. in diameter. This small hole will guide the large drill and allow it to cut faster, as its point has no obstruction to cut through.

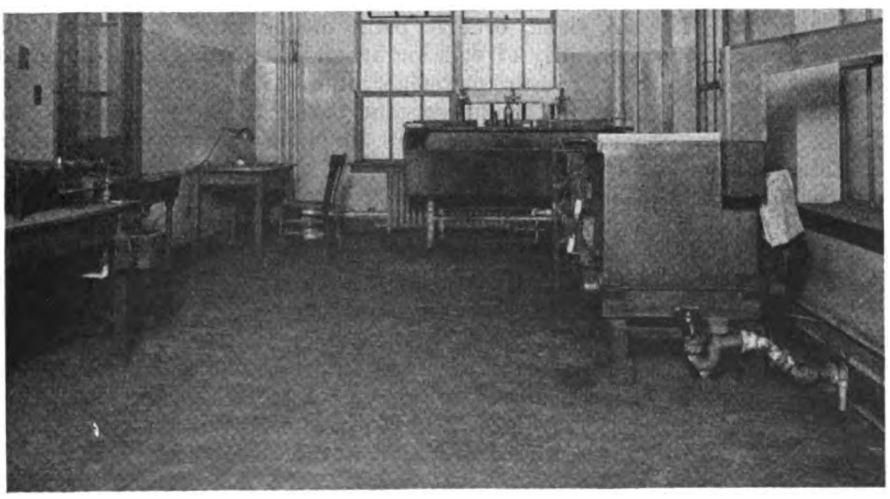
Drills for slate should be sharp. Use the small sizes in a small geared hand-drill and the sizes above ⅜ in. in a common carpenter's brace. The small hand-drill should be worked very fast and under comparatively light pressure, but the larger drills should be worked slowly and with greater pressure. The drills will ther retain their sharp edge and will not neat, but will cut rapidly and cleanly.

Drilling slate at high speed and attempting to cool the drills with water is not good practice as the drills will heat and lose their temper, and the slate dust will form into a thick mud almost at the start. Care should be taken to ease up on

(*Please turn to page 554*)

Here is another case where a slate floor and vats or tanks for acids are giving good service.

The floor is made of sand-rubbed slate and the acid tanks have the same finish. Slate flooring is not affected by the acid that may be spilled on it.



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INDUSTRIAL ENGINEER

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Chicago, November, 1925

Let a Notebook Remember Things You Want to Do

MUCH of the planning of future work and of changes that should be made in departments or in equipment, is frequently "carried in the head" of the operating man. Many times the execution of a good idea must wait until a department is closed down temporarily or a machine is out for repair. The man who relies wholly upon his memory to recall these good ideas will often find that he has not remembered them until too late, and the good idea must then be held over until the next opportunity. By that time it is, altogether too often, forgotten entirely.

Operating men who keep and use notebooks, in which these new ideas are jotted down as they occur, find that by occasionally going over their list of "things to do," they can refresh their memories sufficiently so that the intention is very likely to become a reality when the opportunity offers.

Keeping a notebook has the further advantage that ideas which, although they may appear to be excellent at first thought, do not stand up under the scrutiny of repeated readings, are more likely to be discarded rather than carried out—and regretted later.

More Light Means More Production

WITH the approach of winter, shorter days make production increasingly dependent upon the lighting system. In spite of this undeniable and important fact, more than half of a total of 390 typical industrial plants investigated were considered to be poorly lighted, according to a recent issue of *Light*, the monthly publication of the National Lamp Works of the General Electric Co.

This investigation covered from three to over a hundred plants in each of 12 different industries and showed that 15 per cent were classed as well lighted, 29 per cent as fairly lighted, and 56 per cent as poorly lighted.

What poor lighting is costing the average industrial plant, and the advantages which result when the lighting system is improved, are also well shown in this same publication in the tabulation of the results of tests made on old and new lighting installations in nine different industrial plants. These tests showed that an average increase of 15.04 per cent in production was obtained when adequate lighting was provided, at an average additional lighting cost of 1.96 per cent of the payroll. The lowest increase in production in the nine plants was 4.4 per cent at an additional cost of 0.6 per cent of the payroll, while the highest increase in production was 35 per cent at an additional lighting cost of 5 per cent of the payroll. These tests were made under actual operating conditions in factories before and after an adequate lighting system was installed.

In addition to the increase in production, good lighting yields returns in the way of decreased accident hazards, reduced spoilage, less labor turnover, and other advantages which are difficult to reduce to a dollars-and-cents basis, but are of considerable consequence in industry. Where the advantages of an adequate lighting system and the comparatively low cost of installing it, are fully understood, there is little excuse for the 56 per cent of poorly lighted plants remaining in the unenviable classification in which they now stand.

It is not too late to check over the lighting system in your plant and put it in a higher classification if necessary. The increase in production may go a long way toward repaying the cost of better lighting before the winter is over.

Put Broom and Paint Brush on Your Payroll

THE superintendent in charge of a number of food products plants belonging to one organization recently said that he had in several instances been able to increase production 25 per cent or more simply by cleaning up the plant and giving everything a fresh coat of paint.

It might not be possible to duplicate these same results in every industrial plant, but concerning the value of painting up and cleaning up there can be no dispute. Many plants have found that good housekeeping pays large dividends; and, measured in terms of the payroll or value of the product made, the cost is comparatively small.

A clean, orderly plant means much more than the possibility of walking around freely, without danger of falling over materials and parts scattered over the floor. Cleanliness and orderliness strengthen the morale of the workers and tone up an organization in ways whose value is hard to estimate in dollars and cents. Taken by and large, workmen will do more and better work, equipment will be kept in better condition, and the activities of the plant as a whole will be conducted on a higher plane of efficiency in a plant where housekeeping is properly organized than in one where this is not the case.

Soap and water, and paint, do not cost much, either to purchase or to apply, but when they are used consistently they are an effective means of securing results that are hard to obtain in any other way.

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Have You Any Hard-to-Heat Spots in Your Plant?

INASMUCH as the cold weather season is almost here, special attention may well be given to those difficult-to-heat places around the plant. Nobody denies the need of heat at these places; the only difficulty is in selecting the best method of heating.

As a case in point, the electrical storeroom of a large steel plant was located at one end of a rolling mill building. It was difficult to use steam heat efficiently in this location; hence for several years a coke salamander was placed by the stock tender's desk to warm him between trips after material. Of course, this was a serious fire hazard, but not until a small fire occurred did anyone think to build a small shanty in which were placed a few electric space heaters. This reduced the cost of the heat and eliminated the fire hazard.

In a clock house at this same plant, a large amount of steam was used for heating the large room where the men punched their time cards. Investigation showed that heat was needed only to keep some of the clock house equipment from freezing. Space heaters were installed close to the equipment involved, and the steam was turned off from the clock house, at a saving that was well worth while.

Unit air heaters properly placed often solve the problem of getting additional heat, during the coldest weather, in the central parts of repair shops and other buildings that have large open work spaces that must not be obstructed with steam coils or radiators. The difference between a warm and a cold repairman is often the difference between whether the equipment he is repairing does or does not stand up in service the way that it should.

Each heating job must be considered by itself and carefully analyzed to determine what form of heating should be used. Plant men are always looking for places to save kilowatts, steam power, and other forms of energy. Why not investigate the possibilities that may lie in the plant heating system?

Keep a Copy of the Code on Your Desk

THE biennial revision of the National Electrical Code has recently been completed, and in the article beginning on page 529 of this issue the most important changes of interest to industrial plant men have been outlined and briefly discussed.

The Code, as it is familiarly called, was first drawn up in 1897 as a result of the united efforts of the various insurance, electrical, architectural and other organizations which recognized the need, from various standpoints, including fire risk and personal injury hazards, for greater standardization in the installation of electrical equipment. In the compilation and frequent revisions of the Code, nation-wide sources of experience and practice have been freely utilized, so that while inventive genius is encouraged and economy fostered, what is considered to be a suitable factor of safety is always retained. Largely as a result of adherence to Code rules, modern practice in the installation and operation of electrical equipment reduces to a minimum the potential hazards incidental to the operation and use of such equipment.

Thorough knowledge of Code rules is a valuable asset to every executive who is concerned with the installation or operation of electrical equipment, and may serve to prevent costly mistakes and regrettable accidents. Further, as a reference work the Code contains dependable answers to many puzzling questions as to what is the safe procedure under given conditions.

Copies of the National Electrical Code may be obtained from the National Board of Fire Underwriters, 76 William St., New York, N. Y.

One Man Should Be Responsible for Plant Operation

NOT many years ago the plant electrical department consisted of one man whose job was more or less of a part-time proposition. As the application of electric power to industrial processes became more varied and widespread, the part-time man became an electrician foreman with a gang of men, all of whom were considered as a part of the mechanical department of the plant.

At the present time most of the medium-sized and larger industrial works have a separate electrical department under the supervision of an electrical superintendent. This man divides with the master mechanic or mechanical superintendent the responsibility for the selection, operation and maintenance of all power supply and power drive equipment, as well as the equipment for furnishing light, water, steam, heat, compressed air, and the like. This division of responsibility, however, has its disadvantages. As W. S. Hall, Electrical Engineer of the Illinois Steel Co., says in a recent issue of *Iron and Steel Engineer*:

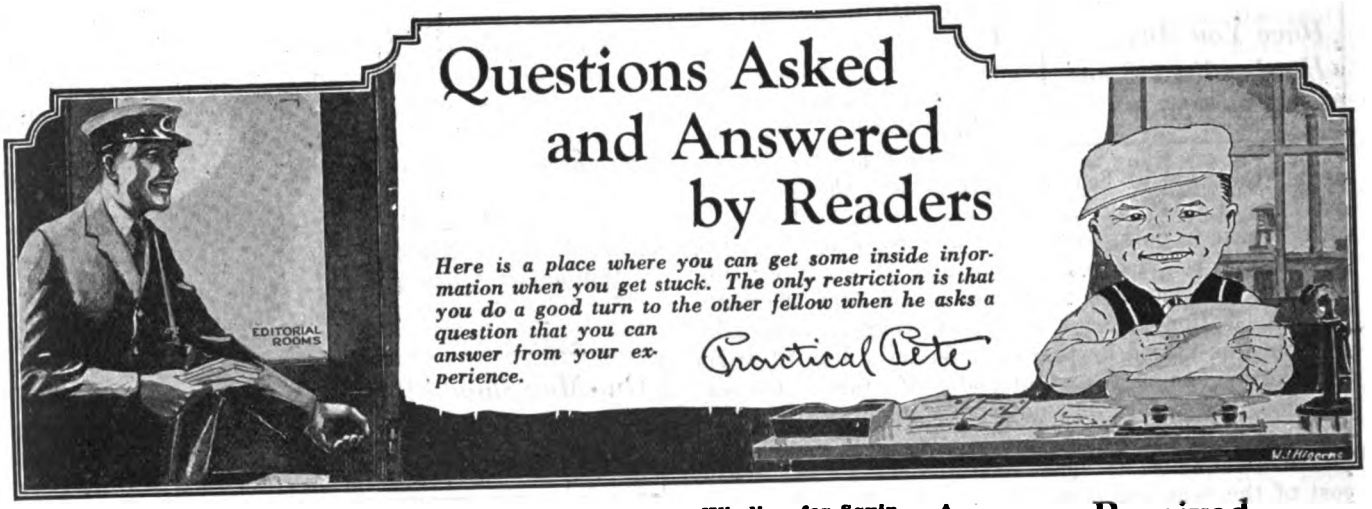
> Experience has shown that where the control and motor are properly applied, electrical troubles which have developed are generally caused by faulty mechanical design or maintenance in the apparatus which the motor drives. It is, therefore, of the utmost importance to have close cooperation between mechanical and electrical maintenance men. So important is this that considerable progress has been made toward developing men with both mechanical and electrical experience. The question of divided responsibility will always be present until such time as both mechanical and electrical supervision are under one man. This practice is being adopted more and more, as fast as the experienced men can be developed, and it is felt that it is the only solution of the maintenance problem.

This man will be a new type; he may be a mechanically-trained electrical man, or possibly an electrically-trained mechanical man. He will be distinguished by various names; he may be known as a maintenance engineer; he may be called superintendent of maintenance or, as is the case in two large steel plants in Ohio, he may have the title of superintendent of mechanical and electrical departments.

Whatever his title, he must be broad-gauged and able to give operating problems well-balanced consideration from all angles. He will not think of a power drive as being a control and a motor with a thingamajig on the end of it to connect it to the machine it drives, nor yet as a machine driven through a reduction gear and flexible coupling by an electrical contrivance that the other fellow can worry about. He will know the essential details about both the mechanical and electrical elements of these drives, together with all the ins and outs of general plant operation and maintenance.

Are you fitting yourself to be that man in your plant?

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

How to Make a Magnet Recharger—I wish to build a coil for recharging or remagnetizing magneto magnets. This coil is to operate on 230 volts direct-current. I shall be glad to get any information regarding dimensions of core, turns and size of wire, and so on, that other readers can give me.
Somerset, Pa. G. G. F.

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How to Support a Mule Stand.—We are planning on a lineshaft installation in which it will be necessary for the shaft to extend across the room, with an additional section to be installed at right angles along the side wall. We have been considering using a mule stand but some of our men who have had experience with this device in other shops advise going to the expense of separating the shafts and using two motors.

I should like to know the methods other readers have used in supporting such stands and lubricating the pulleys and the results they obtained. This is a mill-construction building with a 2 15/16-in. main shaft and a 1 15/16-in. shaft on the extension.
Milwaukee, Wis. R. C. A.

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Proper Babbitt for Armature Bearings—I would like to learn the experience of other readers as to what kind of bearing metal they find to be most suitable for armature bearings. Is a lead-base babbitt best suited for armature bearings of motors, which are geared direct to the driven machine? With what type of bearing metal do you get the best results on armatures that are direct-connected or belted to the driven machines? There are on the market a great many varieties of bearing metal, including babbitt and various bronze alloys, and I shall appreciate any information that you can give me regarding the selection and application of such metal for use in armature bearings.
Pittsburgh, Pa. H. D.

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Low-Voltage Generator Will Not Excite.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.
Stamford, Conn. W. E. H.

Calculation of Rotor Winding for Squirrel-Cage Motor—I have a 1-hp., 220-volt, Type RI, single-phase, General Electric motor, which I wish to rewind for three-phase operation. I have calculated the winding for the stator, but do not know how to go about figuring the squirrel-cage winding for the rotor. Can any reader give me some help in this matter?
Oakland, Calif. B. B.

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Measurements Required for Bending Conduit.—When bending conduit by use of a hickey, what measurements should be taken for making an offset, so that I can bend several conduits and have them match when placed side by side? I find it hard to get both sides the same on a double offset. Can some reader tell me how I can make a good-looking job by the use of a hickey on this kind of bending? If any readers have other devices or methods for making double bends and offsets I should like very much to know about them.
Worcester, Mass. R. S. T.

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Effect of Turning Rotor on Split-Phase Motors—I recently had to make repairs on some split-phase motors, and found it necessary to turn down the squirrel-cage rotors. I wish some reader would tell me what effect this would have on the motor characteristics, such as speed and capacity? Also, can some reader tell me how to reverse the direction of rotation on shaded-pole type motors? What is the rule for determining the direction of rotation on such motors?
Hood River, Ore. V. G. W.

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What Is Wrong with the Method of Rewinding This Armature?—I have a Willey electric drill, serial No. 20063, 110 volts, a. c., 6 amp., Type 4 U. C. 2, which is manufactured by the James Clark, Jr., Electric Co., Louisville, Ky. The armature has 17 slots and 32 bars, and is wound with No. 23 cotton-covered enameled wire, using 13 turns per section, with a coil span of 1 to 8, and the leads checking straight out. The armature is hand-wound, left-handed, with the commutator to the right. The only change was that I rewound it right-handed instead of left-handed. I expected that the motor would reverse its direction, which it did. When the drill was connected to the line, both brushes sparked badly, which convinced me that they were off their neutral position. I moved the brush holder to different positions around the commutator, but could not find the neutral point. I took the brush holder head off and checked the leads, which were O. K. Finally the armature was stripped and rewound the same way as before except that I changed the span of the coil from 1 to 8 to 1 to 9. Without moving the brush holders from the position set at the factory, the drill operated perfectly. Why would this armature not operate with the coil span 1 to 8 and wound right-handed? Would winding this armature right-handed instead of left-handed have any effect besides reversing rotation?
Richmond, Va. H. F. S.

Answers Received To Questions Asked

Will Flexible Couplings Reduce Gear Shock on Motors?—I would like to obtain the views of some of our readers on the value of a flexible coupling in preventing the shock and vibration of gears from reaching the motor armature and commutator. We have encountered some trouble from vibration and gear shock affecting commutators and I am wondering if flexible couplings between the motor and the gear drive would help me in eliminating this trouble.
Omaha, Neb. M. P.

Replying to M. P.'s question, I have used flexible couplings on all kinds of drives, including small and large centrifugal pumps operating at 1,750 r.p.m.; also on geared hoists of 100 to 300 hp. operating at 400 r.p.m. and having straight and herringbone gears, with satisfactory results. Several have been in continuous service for nine years without any repairs. I have also had good results in using cloth pinions (made up under various trade names) for absorbing the shock on motor shafts of small and large geared reciprocating pumps, deep well pumps and other heavy equipment. The character and conditions of load, with reference to speed and location of motor, would be the deciding factor in favor of the flexible coupling or silent pinion.

WILLIAM J. MILDON.
Supt. Power & Equipment,
Madeira Hill Coal Mining Co.,
Philipsburg, Pa.

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Treating Windows to Prevent Glare.—I would like to obtain the experience of other readers in treating windows to prevent glare from the sun, particularly on western exposures during the late afternoon. At times this is almost unbearable in parts of our shop. What treatments, if any, have other readers found satisfactory; or would it be better to use shades and, if so, what kind?
Des Moines, Iowa. D. J. C.

With reference to the question recently asked by D. J. C., it will not be necessary for him to use shades to eliminate the glare from the sun.

Proper treatment with a window coating will in most instances entirely eliminate the glare. Ordinary whiting or white wash is sometimes used, but if a study were made of the results obtained, this type of coating would not be considered desirable.

Mr. J. J. McLaughlin of the Illuminating Bureau of the Westinghouse Lamp Co., states that white surfaces

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reflect 82 per cent of the light, green 70 per cent, yellow 67 per cent, red 20 per cent and blue 15 per cent. From these figures it is evident that blue would be the most desirable color for a coating.

The material should be one that is easily applied, will not rub off under ordinary conditions and yet can be easily removed if necessary. A product which meets these requirements is being sold on the market today.

Park Chemical Co., Cincinnati, Ohio. A. J. LODDER.

* * * *

Contactors Will Not Close on Low Voltage.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?

Omaha, Neb. M. P.

In answer to M. P., I would suggest that he try shortening the air gap of the contactors that will not close on low voltage. Quite often there is some means provided by the manufacturer for the adjustment of this gap between the armature and the magnet core of the contactor. If there is, M. P. should find it and use it.

In case no such provision has been made, a little ingenuity on his part should enable him to effect a reduction in this air gap so that the contactor will surely close on low voltage. This adjustment will, of course, make the contactor go in with quite a bit of force when the voltage is up to its full value. If this is objectionable it will be necessary to rewind the contactor coil, which is a job to be referred to the manufacturer.

Gurney Elevator Co., New York City. J. M. WALSH.

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How to Determine Horsepower of a Shaft or Clutch.—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required.

I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m

Grand Rapids, Mich. E. E. H.

Our experience in determining the rating of power transmission equipment, as asked by E. E. H., has been that over ordinary ranges of speed up to 350 to 400 r.p.m., on many drives, the element of shock does not enter far into the question of clutch selection, and that horsepower ratings are nearly proportional as far as securing results goes.

However, the inertia and acceleration of a considerable amount of machinery are important factors and must be allowed for, in higher speed work, above 300 r.p.m., which may be what E. E. H. has in mind. I think most clutch makers append such a caution to their tables and it is very necessary to take this into consideration, since the inertia of rotation of a line of shafting quadruples with double the speed. Due to the careless way some operators throw in clutches, something is likely to go at the higher speeds.

Our clutch-driven machinery is all very heavy and our men are carefully trained to slip the clutches and pick up speed on the driven end before plugging them in.

Where clutches are used frequently, that is several times a day or oftener, I would recommend using a clutch of one-third to one-half greater horsepower rating, in order to give longer life with reasonable wear.

I am sorry that I cannot give E. E. H. more definite figures, but our estimate of the horsepower on each clutch is pretty much of a guess, although it makes out fairly well, as far as service and lack of trouble go.

Plant Engineer, New Haven Pulp & Board Co., New Haven, Conn. H. D. FISHER.

* * * *

In regard to the question asked by E. E. H., there is some difference in the way manufacturers rate different kinds of transmission machinery, such as lineshafts, clutches, gear reductions, belt drives, bearings, flexible couplings, and so on.

It makes little difference, however, whether such operating devices are rated in horsepower per 100 r.p.m. or in horsepower per r.p.m. The main things to keep in mind are the normal and maximum horsepower to be transmitted by a given drive; the normal and maximum operating speeds for that drive; whether it is to be operated intermittently, for 8 to 10 hr. daily service, or for continuous service, 24 hr. per day; whether it is subject to any shocks and vibrations; the general nature of the installation; and what kind of operating attention it is likely to receive after it is installed.

Much of the transmission machinery installed in the usual small machine shop drives, up to perhaps 25 hp. or 50 hp., is for the purpose of transmitting relative motion rather than for any real or definite amount of power. The starting load or the occasional maximum power requirement may call for a certain motor size, yet in normal operation only half or even one-third of this power may be needed. If the shafts, bearings, pulleys, belts and clutches are adequate for the maximum requirement, it makes little difference whether they operate at 100 r.p.m. or 250 r.p.m., the latter being somewhere near the average operating speed for such drives.

It is usual practice to double the size of equipment for shock loading, such as when a gas engine is used rather than an electric motor, and of course some allowance should also be made because of the nature of the driven machines, such as whether they require a continuous input of power or whether they are intermittently loaded, as in the case of punch presses, and so on.

Take, for example, the simplest kind of transmission machinery—a piece of shafting. Most manufacturers give the highest rating to a given shaft when it is used for the simple transmission of power without any bending strains or shocks; they recommend about two-thirds of this rating for lineshafts subject to usual conditions of bearings about every 8 ft., and with pulleys giving side strains or small bending moments; however, they recommend only about 40 per cent of the first rating for headshafts, gearshafts and other shafts subject to heavy bending stresses. The capacity ratings of such transmission shafts are generally given from 50 r.p.m. up to 500 r.p.m. in the smaller sizes, the usual or average operating speeds being perhaps 200 r.p.m. The larger sizes are usually tabulated for operating speeds from 50 r.p.m. to 200 r.p.m., not a very wide range.

The shafts of electric motors are generally about seven times as powerful as shafts for the simple transmission of power without bending stresses. For example, 1⅞ in. transmission shafts are rated for about 3 hp. per 100 r.p.m., while a 7½-hp., 1,800-r.p.m. (or 5-hp., 1,200-r.p.m.) motor shaft is generally about 1¼ in. in diameter. This is at the rate of only 0.4 hp. per 100 r.p.m.; 3 divided by 0.4 gives an additional safety factor of over 7. Larger motor shafts are generally required to give the necessary rigidity to the drive, to provide adequate area for the bearings, and to take care of shocks and bending moments where pulleys, gears or chain sprockets are mounted directly on the end of the motor shaft.

The crank shafts of Diesel engines are proportionately somewhat larger than motor shafts because of the shock loading and heavy bending stresses, even for the same average torque rating.

It will be seen, therefore, that there are conditions even as important, if not more important, than the matter of operating speeds that govern the size of as simple a piece of equipment as a shaft is generally considered.

When it comes to the question of capacity in relation to operating devices such as flexible couplings for direct-connected and geared drives, the basic calculation for size is made upon the torque capacity of the coupling. One must also consider the operating speed, whether the coupling is going to operate at perhaps 10 or 50 r.p.m. on the low-speed side of a reducer drive, or whether it is going to operate at perhaps 600 or 1,800 r.p.m. on a motor drive, or perhaps 3,600 r.p.m. on a turbine. One must also consider the nature of the connected machines, such as whether the loading is smooth and not subject to shocks and vibrations, as a motor-driven contrifugal pump; or whether the coupling is subject to heavy and continuous shocks and pulsations, for example, when a Diesel or internal combustion engine is directly connected to an ammonia compressor.

The range of direct-connected and geared drives, where a flexible coupling can be economically employed to insure against operating troubles due to accidental shaft misalignments, is very

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great. In our catalog ratings of Francke flexible couplings we list the theoretical ratings to give certain material stresses and certain bearing pressures which we have found by calculation and by years of experience to be correct for maximum conditions on absolutely smooth torque drives. By a system of "Service" or "Operating Factors," we reduce these capacity ratings by an amount sufficient to take care of the usual peak overloads, to take care of shocks and vibrations, and to take care of the usual operating conditions incidental to motor, turbine and engine drives when these are connected to many different kinds of ultimately driven machines. The use of the proper service factor is just as important as the basic calculation of machine horsepower rating in relation to the operating speed.

We do make some allowance for the operating speeds, as for instance in the case of rubber mill drives where we use a Service Factor of 4 to insure a coupling of sufficient size to provide both strength and wearing qualities to last many years for the high-speed coupling to transmit perhaps 200 hp. normal and 400 hp. maximum at 600 r.p.m. from the motor to the pinion shaft. However, another coupling is usually used between the slow-speed gearshaft to connect it to the millshaft. This usually transmits from 200 to 400 hp. and operates at only 80 or 90 r.p.m. Depending upon the number of mills taking power from this millshaft, we employ a Service Factor as low as 2 to determine the size of the low-speed coupling. This provides a coupling powerful enough for the maximum peak load or torque conditions. It also provides a coupling with wearing qualities adequate to operate at 80 r.p.m., whereas the high-speed coupling probably will be subject to less wear and less misalignment stress at each revolution, but, however, it makes perhaps six to ten revolutions to every one made by the low-speed coupling.

It will be seen, therefore, that while we list the capacities of our couplings at 100 r.p.m., the Service Factors employed take into account the usual operating speeds for the different kinds of operating machines, as well as the nature of the loading, and other operating conditions, just as important as the operating speed. These factors are the result of operating experience rather than theory alone, and it is always our endeavor to obtain full specifications of the drive for each coupling so that we can employ that experience to insure the correct size and type of coupling for each particular drive. The same is true of practically all other well-established manufactures of power transmission equipment.

Smith & Serrell, Newark, N. J. JOHN J. SERRELL.

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In answer to E. E. H.'s question, couplings, clutches and other transmission equipment are designed on a basis which allows 200 to 300 per cent greater starting torque than the required running torque, plus a factor of safety for the mechanical elements. There are two types of loads which must be considered: machine duty, or constant torque, where the torque required is constant for all speeds; and what might be termed fan duty, where the torque required varies with the speed. Machine tools, reciprocating air compressors, pumps, printing presses and so on are of the first constant-torque type, and centrifugal pumps, blowers, fans, and so on, belong to the second type.

Let us assume an example: A group of machines is driven from a lineshaft and this shaft is to be coupled at one end to another section of shaft by means of a rigid or flexible coupling or clutch. Assume that 10 hp. are required to drive the first section at a shaft speed of 100 r.p.m. A coupling or clutch rated at 10 hp. at 100 r.p.m. will transmit the required running torque and take care of the greater starting torque which is due to the static load. Let us then assume that the speed of the shaft is to be increased to 200 r.p.m. with all other conditions unchanged. In the first case a 10-hp. motor was used, but changing the speed of the driving lineshaft now requires a 20-hp. motor. The question is, what about the coupling or clutch? This will not need to be changed, because of the nature of the load, which requires constant torque, and only the speed is changed, since no greater starting or running torque is required, as shown from the following equation:

$$Horsepower = (T \times D) \div 33{,}000$$

Where T=torque in pounds, and D=distance traveled in ft. per min.

By comparing the first case, in which the shaft turns at 100 r.p.m., with the second, where it turns at 200 r.p.m., it will be observed that since the torque T remains the same for both cases and D is twice as great in the second case as in the first, the horsepower is double in the second case, as indicated by the following:

$$2 \times Hp. = (T \times 2D) \div 33{,}000$$

However, if there is no change in speed but if another section of shaft is added or a greater number of machines are driven from the same shaft, equal to an additional 10 hp. torque load, then the coupling or clutch would necessarily have to be changed as the torque T is twice as great, the speed remaining 100 r.p.m., as noted from the equation:

$$2 \times Hp. = (2T \times D) \div 33{,}000$$

It should be noted that in the above equation $2 \times Hp.$ does not mean two horsepower, but means that the horsepower is multiplied by two. Also, that for the same horsepower different size couplings or clutches must be used, depending upon the speed.

Another point to be considered in the selection of a proper coupling or clutch is the load factor, which depends upon the kind of service and nature of the load, and is considered in designing power transmitting equipment. Load factors vary from 1 on steam-turbine-driven generators to 4 on gas- or oil-engine-driven mine hoists.

For example: Suppose a coupling is required for an air compressor driven by a 40-hp., direct-connected steam engine at 200 r.p.m. The horsepower rating of the coupling is based on 100 r.p.m.; this basic rating is determined as follows: $(40 \times 100) \div 200 = 20$ hp. per 100 r.p.m. A table of load factors, such as is given by the manufacturer of couplings in his catalog, shows that for air compressors driven by a steam engine the load factor is 3. Then multiplying, $20 \times 3 = 60$, which is the horsepower rating required at the equivalent speed of 100 r.p.m. A coupling of this rating is chosen.

E. H. LAABS.
Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

The following discussion will, I believe, help to answer E. E. H.'s question on the rating of power transmission equipment. The formula for horsepower transmitted is:

$$Hp. = (P \times \pi \times d \times R) \div 33{,}000,$$

where P=torque or pull; π=3.1416; d=diameter; R=revolutions per minute. In this formula the quantities, $\pi d \div 33{,}000$, are constant for a given diameter of pulley; therefore, the horsepower will vary as PR. Now, if a clutch always exerts a pull P at the pulley rim then P is a constant, too, and as far as the formula is concerned the horsepower varies directly as R (the revolutions per minute). This reasoning applies particularly to a clutch which is engaged standing still; when the shaft revolves 100, 250, or 500 revolutions it is evident that, if no slip occurs, the horsepower will be proportional and, as in the example quoted, the horsepower will be 10, 25, or 50 hp. respectively per 100, 250, or 500 revolutions.

However, in starting, the friction of rest (caused by metallic bearing contact without proper oil films or by the adhesion of belts) must be considered, together with the inertia of the complete mass which must be set in motion. These two resistances may be considerable and in some cases may demand a clutch pull much heavier than is ever called for after the shaft is up to speed.

If the same shaft, bearings, pulleys and belts are set in motion at 100 r.p.m. and then again at 250 r.p.m. and then again at 500 r.p.m., it is obvious that the same clutch pull is required at the moment of starting in all three cases. Therefore it would seem that the same clutch is all that is required. Of course, the clutch must not grab the load suddenly like a positive jaw clutch. That would mean disaster at almost any speed and certainly a worse disaster at the higher speeds. Heavy inertia loads like large fly wheels must be started and brought up to speed gradually. To do this, a friction clutch must be thrown in little by little until it is finally locked in engagement.

Starting an automobile slowly is a typical example of slow clutch engagement in order to overcome the friction of rest and the inertia of the mass. The heavier the load the slower must the automobile start to move. However, here the analogy ceases, because the automobile engine has a quite definite power pull and if the resistance met is too much the clutch must slip or the engine is stalled. In power transmission, on the other hand, there

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is usually a surplus of power pull and the result is more likely to be a destructive slipping of the clutch or something must break. The automobile clutch has a fixed spring pressure against the friction members which compensates for wear, while the power transmission clutch is toggle-locked, when engaged, and there is no compensation for wear except by a new setting of the friction surfaces. The latter clutch, therefore, has a fixed pull between the friction members only when in the locked position.

The answer to this practical question lies in the ability of the power transmission clutch to slip when required and yet not have enough destructive wear on the soft friction surfaces to prevent repetitions of engagement. Hardwood or some form of firm asbestos brake lining are usually employed for the soft friction surface, although aluminum and copper are sometimes used in shafting clutches.

Test of clutches on a prony brake always indicates the development of heat in starting under load. The higher the relative speed of the two members of the clutch the greater the heat produced. If the time of engaging the clutch is prolonged, in order to start the load, and the speed is high, then inevitably the heat chars the soft friction surfaces and destroys the pulling power of the clutch. In such cases it may be found that when the clutch is fully engaged it has no longer sufficient grip to pull the load. It must then be readjusted; too frequent clutch adjustment is annoying. The obvious procedure then is to use a larger clutch with larger friction surfaces to reduce the wear and the frequency of adjustment. This can often be done with satisfactory results, but not always. It happens that as the clutch becomes larger in diameter the friction surfaces are also farther out from the shaft and their relative speed is actually increased; the effect, therefore, of larger clutches for higher speeds is more or less neutralized.

The judgment of experience seems to be the only guide in proportioning the clutch size to the speed.

Chief Engineer, HARRY J. SMITH.
The Hill Clutch Machine & Foundry Co.,
Cleveland, Ohio.

* * * *

Does Change in Transformer Connections Affect Rated Capacity?—I have three 100-kva., single-phase, 2,200-110-volt transformers, which I intend to connect in a bank to deliver three-phase power at 110 volts. If a delta-delta connection is used to connect the bank, what power capacity can I get from the transformers? Will I get the same power capacity from a star-star connection? I shall appreciate any information that readers can give me on this question.
Telluride, Colo. T. H. C.

Answering the question by T. H. C., it may be said that he has no choice of connections to use other than that which will give rated voltage on each transformer.

As the rated voltage of the transformers is given as 2.200/110 a delta-delta connection should be used if the primary voltage is 2,200 volts; this will apply 2,200 volts to each transformer. If the primary voltage is 3.800 volts a star-delta connection should be used which will give 3,800÷1.73 or approximately 2,200 volts applied to each transformer. It may be mentioned that any increase or decrease in primary voltage will directly affect the secondary voltage, in this case by the ratio of 20 to 1.

Denver, Colo. JOHN E. HOLTMAN.

* * * *

In his question, T. H. C. did not mention the voltage to which he intends to connect the transformer bank. Assuming that the voltage of the service to which the transformers are to be connected is 2,200 volts, the capacity of the bank connected delta-delta equals phase voltage×phase current×3. With this connection the phase voltage and line voltage are equal and the full-load phase current of a 100-kva. transformer will be 45.5 amp. Hence, the output of the transformer bank will be 2,200×45.5×3=300 kva.

With the star-star connection, the phase voltage or voltage impressed across the transformer primaries is line voltage÷√3, while the phase current equals the line current equals 45.5 amp. Hence, the full-load output of the transformers with a star-star connection on a 2,200-volt supply will be (2,200÷√3)×45.5×3=173 kva.

I hope that this will give T. H. C. all the information necessary.

Chicago, Ill. A. NOEPPEL.

* * * *

In answer to T. H. C., changes in connections of the three 100-kva., single-phase, 2,200/110-volt transformers, would not alter the capacity of the transformers as long as they are operated at the voltage for which they are designed. The 220-volt primary coils of a 100-kva. transformer will carry 45.5 amp. at full load. With the three transformers connected delta-delta on a 2,200-volt system, the primary coils of each transformer will be carrying 45.5 amp., the line current will be 78 amp. or 1.73 times the current in the primary coils, and the output of the bank of three transformers will be 300 kva. If these transformers were connected star-star to a 2.200-volt system, the voltage across the primary side of each transformer would be 2,200÷1.73 or 1,271 volts. With each transformer carrying full-load current of 45.5 amp. the output of each transformer would be 1.271×45.5 =58 kva., and the capacity of the bank would be only 3×58=174 kva.

The usual conditions under which 2,200/110-volt transformers are connected in star, would be with a line voltage of 3.800 volts and the transformers connected star-delta. In this case each transformer would have 2,200 volts across its primary and with 45.5 amp. primary current would be carrying a load of 2.200×45.5=100 kva. The output of the bank would be 3×100= 300 kva., and with the secondary side connected in delta, the secondary voltage would be 110 volts, since the transformer voltage ratio is 2.200/110 volts.

The use of 2,200/110-volt transformers in this way has usually come about through an increase in line voltage from 2.200 to 3.800 volts. This gives the utility company increased line capacity at small expense, since the same transformers can be used. The generators may be so arranged that the ends of each phase winding are brought out giving six terminals; hence the windings may be connected in either delta or star. If in delta, the terminal voltage will be 2,200 volts; if in star, 3,800 volts. If the utility company's lines are operating at 2,200 volts, three-phase, three-wire, and it is desired to increase the line voltage to 3,800 volts, the generator windings are reconnected in star and usually the common point of the star is grounded and is also connected to a fourth wire, giving a three-phase, four-wire system. The voltage between the first three wires is then 3,800 volts and the voltage between any one of these and the fourth wire is 2,200 volts. The primary sides of all of the transformer banks are then reconnected in star and will operate with a line voltage of 3,800 volts and will have 2,200 volts impressed across the primary of each transformer. With the secondary connected in delta, 110 secondary volts will be obtained. The fourth wire with any one of the others provides a 2,200-volt primary supply for the single-phase lighting transformers, which can be balanced across the three phases.

If T. H. C.'s primary voltage is 2,200 volts, his transformers should be connected, delta-delta to give 300 kva. with a secondary voltage of 110 volts. The transformers should be connected star-delta if his line voltage is 3,800 volts and should not be connected star-star in any case if it is desired to operate them at their rated capacity of 300 kva., with a secondary voltage of 110 volts. If the star-star connection were used under these conditions, the secondary voltage would be 110×1.73 =190 volts, which is a higher secondary voltage than would be desired for a 110-volt secondary circuit.

East Cleveland, Ohio. L. J. JOHNSON.

* * * *

Method of Cleaning Motor Winding—What is the best method of cleaning motors that are oil-soaked and dirty? Can they be washed in gasoline and baked out in a bake oven to any advantage? What is the best method of handling the gasoline? Should the armatures be dipped in a trough containing gasoline, or should they be wiped with a gasoline-soaked rag? I would greatly appreciate hearing of any other methods used by readers for cleaning oil-soaked windings, as well as the results obtained by using gasoline for cleaning.
Chicago, Ill. R. W. A.

With reference to R. W. A.'s question, machines that are dirty and dusty, but not oily, may be readily cleaned with dry compressed air. In using compressed air, be careful not to direct the air stream into the oil wells or you are likely to have oil sprayed all over the windings.

If the machine is oily and dusty, it should be disassembled, the windings scraped with tools which have no cutting edges, and then washed with gasoline or naphtha, using stiff bristle brushes. If you have a nozzle arranged for air and naphtha, similar to those used for spraying paint, you can use it to advantage. In all cases when using compressed air, direct the stream so that material will not be blown into

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any crevices in and around the winding.

Remember that this work should be done in a well-ventilated room. Keep away from flames or fire. Do not apply any dielectric tests until you are sure that the gasoline has entirely evaporated.

C. N. SHAFER.
Supt. Service Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

* * * *

With reference to R. W. A.'s question, a method that I have found very satisfactory is to squirt a stream of gasoline from a blow torch into the windings. When applied in this way the gasoline penetrates the small spaces that you cannot get into with a rag. At the same time the windings are not soaked, as is the case when they are dipped in gasoline. When cleaned in this way, I think that a motor will dry out enough in a few hours to be put back into service without baking.

Louisville, Ky. WILLIAM F. GARCIN.

* * * *

Answering R. W. A.'s question regarding the care of motors, the prevailing practice at U. S. Nitrate Plant No. 2, where there are some 600 motors, ranging from 400 hp. down, to be kept in first-class condition, is to remove the rotor and then clean off all rust from metal parts. We use a gasoline spray to clean all parts thoroughly, and when they are dry we apply a good grade of air-drying insulating varnish. This varnish is applied with the same spray as is used for the gasoline, and by using about 60 lb. per sq. in. air pressure, all surfaces are reached.

In cases where motors are affected by dampness it is well to apply one coat of Ozite, a pothead compound made by Standard Underground Cable Co., Pittsburgh, Pa. This is prepared by first heating to a liquid state and adding sufficient gasoline to make it easily applied with brush. The gasoline will evaporate, leaving a good coating of damp-proof insulation. It is best to apply this when warm.

The spray used is a home-made affair, in which the materials to be applied are syphoned into the head and thereby broken up by the air. The density of the spray is controlled by a valve in the suction line.

Plant Engineer. J. F. GORDON.
U. S. Nitrate Plant No. 2,
Muscle Shoals, Ala.

* * * *

Replying to R. W. A., regarding method of cleaning motor windings, I have got excellent results by using gasoline and compressed air, at about 60 lb. pressure. For this purpose a small tank will be best, since in some cases the motors are in inaccessible places or on the side of a wall, and an outfit that can be carried easily is necessary. An old Presto-Lite tank can be used, if one is available. Fit the tank with a small pipe extending from the outlet to within about an inch of the bottom, on the inside. The outer end of this pipe should be provided with a valve and a hose connection.

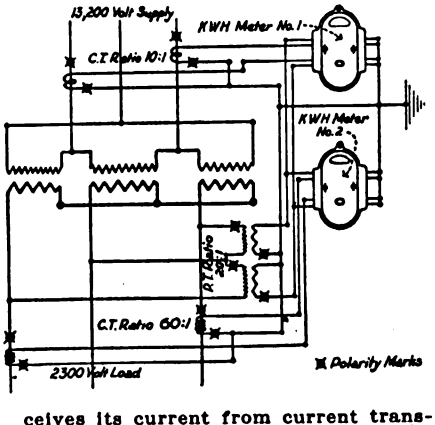
Another piece of pipe should be screwed into the top of the tank and likewise provided with an air valve and hose connection for connecting to the air line.

When the tank is ready fill it about two-thirds full of gasoline and connect the short pipe (the one that just goes through the top of the tank) to an air line of about 60 lb. pressure per sq. in. When the air is turned on it will cause a fine spray of gasoline to be forced up through the long pipe. By means of a short piece of hose this spray can be directed to any part of the winding, and the dirt and oil will soon be loosened and blown out without harm to the winding, as the gasoline will soon evaporate. No oven will be needed to dry the motor.

Service Dept., M. V. MILLER.
Westinghouse Elec. & Mfg. Co.,
Indianapolis, Ind.

* * * *

Will These Watt-hour Meters Read Alike?—The diagram shows a proposed method of connecting watt-hour meters on the primary and secondary sides of a bank of transformers connected delta-star. As shown, the meter measuring the high-tension power receives its current from current transformers in the lines supplying the delta-connected primary, while the potential supplied is the low-tension line voltage. The low-tension watt-hour meter is connected in the usual manner. I should like to know if this connection for No. 1 meter will work satisfactorily. Also, if we disregard the copper and iron losses in the transformers will there be any difference in the records of the two meters at unity power factor, and at 85 per cent, 70 per cent and 45 per cent lagging power factor, assuming that the load is always balanced?



Longview, Wash. J. C. R. C.

Referring to J. C. R. C.'s question in a recent issue, I would not recommend the watt-hour meter connections shown in the diagram. The principal reason for installing watt-hour meters in both the primary and secondary sides of a transformer bank would be to determine the power loss in the transformers themselves. The greater portion of this loss is due to voltage drop in the windings caused by resistance, hysteresis, and eddy currents. In order to have these losses included in the reading of the supply meter it would be necessary to have the potential coils of this meter energized at the primary side.

The hysteresis loss and the reactance of the coils produce a reactance component in the impedance of the windings, which results in the voltage induced in the secondary being slightly out of phase with that in the primary. This phase angle is much greater in power transformers than in instrument transformers. It also varies with the power factor of the load, as do the copper and leakage losses. Therefore, there would be a variation in the readings of the two meters with every change in power factor, in addition to the error from the first-mentioned cause.

However, the two meters could not be made to check even if properly connected, as meter No. 1 includes the transformer losses, which are variable. The connections illustrated would give correct rotation, providing the transformers were additive polarity. Otherwise the potential or current connections at meter No. 1 should be reversed.

Chief Electrician, LYLE HENDRICKS.
Pickands, Mather & Co.,
Hibbing, Minn.

* * * *

Referring to the question by J. C. R. C. in a recent issue, this connection will not be satisfactory for No. 1 meter.

Taking the diagram just as it is now, the current transformer on the left leg of the high-tension side should be changed to the center leg, thus placing current and potential of the same phase on the lower element of No. 1 meter. Now, assuming that the meters are properly calibrated, the two meters will read exactly alike which, of course, is incorrect, as both meters will be registering the output on account of the potential transformers being on the low tension side.

The best thing to do in this case is to use a separate pair of potential transformers on the high-tension side; then the input will be metered on No. 1, and the output on No. 2.

Under these conditions, the difference in the readings will be the transformer losses only, as the varying power factor, being purely a load condition, will affect both meters alike.

Detroit, Mich. J. J. CONWAY.

* * * *

Answering the question by J. C. R. C. in a recent issue, the metering arrangement which he shows is incorrect. It is evidently desired to eliminate the use of 120 to 1 potential transformers for meter No. 1. I believe it will follow from the discussion below that an installation of enough importance to require a meter on the high side of a transformer bank, such as is described, is also of enough importance to justify the correct potential transformers on the high side, for accuracy.

A short consideration of the phase relations of the potential which should be applied to the potential coils of No. 1 meter, and the phase relation of that actually applied, will show why the installation is incorrect. Calling the transformers from left to right *a*, *b*, and *c*, the potential coil in the upper element of No. 1 meter should be excited by a voltage in phase with the voltage of the high side of transformer *c*. It is actually excited by a voltage which is taken from the potential transformer across the leads of transformers *b* and *c*. If this potential were in phase with that of transformer *c* or in phase opposition to it, connections could be made correct, disregarding the errors in the power transformers. However, the voltage applied is leading the volt-

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age which should be applied by 30 deg. In addition, the diagram shows the primary line voltage to be 13,200 volts and the secondary line voltage to be 2,300 volts, which indicates that the transformers are not of straight ratio. If they were the secondary line voltage would be 2,200 volts. Therefore, it would be necessary to include this odd ratio in the calculations to find a new constant for the meter.

However, consider that all constants are correct and that it is desired to find a new constant to correct the condition of the meter voltages being 30 deg. out of phase. The effect of the actual voltage across the potential coil leading the correct voltage by 30 deg. would be that the meter would measure power the same as though the current were lagging 30 deg. more than it does in fact. For example, if the meter were metering power whose current was lagging 10 deg. with a power factor of .984, the meter would measure the power as though the current were lagging 40 deg. with a power factor of .766. Assuming different angles of lag and continuing the calculations of finding power factors, it will be seen that there would never be a definite ratio between the correct power factor and the power factor for which the meter is corrected. Therefore, no constant could be applied to make the readings correct.

The obvious thing to do would be to install a separate set of potential transformers on the high side of the bank. It would also be possible, although not good practice, to connect another set of potential transformers on the low side, using transformers *a* and *c* and connecting each potential transformer from the line to the star point. However, since it is evidently desired to measure transformer losses in kilowatt-hours the percentage of error in metering, caused by the fact that power transformers do not have as correct a ratio of transformation for all loads as do potential transformers, might be greater than the percentage of transformer loss.

Answering the latter part of the question, if the meters were correctly connected and calibrated there would be no error regardless of balance or value of power factor.

Toronto, Ohio. HERBERT KING.

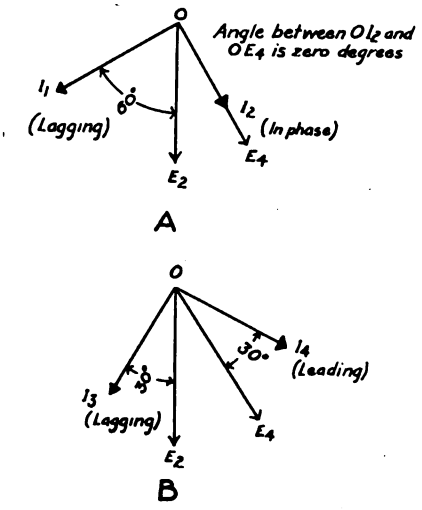
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Answering J. C. R. C. in a recent issue, the two meters connected as shown will not register the same.

Meter No. 2 will register correctly under all conditions of power factor. Meter No. 1 will vary in its registration depending upon the power factor, since it is incorrectly arranged. The reason for its incorrect registration is the angular relation of the current and voltage introduced through the star-delta connection.

At 100 per cent power factor, meter No. 1 has one element in which the current is in phase with its voltage, while in the other element the current lags 60 deg. behind its voltage. In the case of meter No. 2, the current in one element leads its voltage by 30 deg., and the other lags behind 30 deg.

The relations of current to voltage in meter No. 1 are correct for the registration of the total energy used, and are shown vectorially for 100 per cent power factor in diagrams *A* and *B*. In diagram *A*, OI_1 and OI_2 represent currents in the 13,200-volt line; OE_2 and OE_4 represent the voltages between the 2,300-volt lines.



Vectorial relations of current and voltage at 100 per cent power factor in meter No. 1, shown at A, and in meter No. 2, shown at B.

The approximate relations of the registration of the two meters for the power factors listed are as follows:

POWER FACTOR	METER No. 1	METER No. 2	RATIO OF 1÷2
100	1.5	1.732	0.886
85	0.8185	1.472	0.556
70	0.4308	1.2084	0.356
45	—0.0987	0.7792	—0.127

This tabulation assumes of course that the load is always balanced. It should be noted that at 45 per cent power factor, meter No. 1 will run backward. Referring to the diagram, only the actual vectors which are involved, have been given. This was done to avoid confusion and to aid in making the relations clearly and easily understood.

As previously stated, the relations shown in the diagram are for 100 per cent power factor. For all lagging power factors, the current vectors will swing in a clockwise direction. For instance, at 45 per cent power factor, the angle between E_2 and I_1 will become 123.3 deg., and 63.3 deg. between E_4 and I_2.

It is also assumed that both meters are arranged for direct reading without the use of a constant, or in other words, have the correct gear ratio to suit the current and voltage transformer ratios.

This method of metering has been used but usually only with delta-delta connected banks, making allowance in meter No. 1 for the transformer losses by adjustment or other compensation. The correct solution in this particular case would be to install 13,200-volt meter voltage transformers.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

Use of Armored, Lead-Sheath Conductor Underground—Will some of the readers of INDUSTRIAL ENGINEER please give me their experience with the use of 2,500-volt, lead-encased, steel-wound wire such as is put out by some of the large manufacturers and intended to be used underground, and not protected by conduit?

San Diego, Calif. W. P. B.

In answer to W. P. B.'s request for information on the use of armored, lead-sheath conductor underground, I would like to state that we have roughly 10,000 ft. of this kind of cable in use at the present time.

It is used for power and lighting mains and is buried in the ground, with no protection whatever. It has been in use for the past ten years and we have had no trouble with it, although the lines have been moved in some cases two or three feet when making additions or alterations to buildings. So far as we can see, these lines are today in as good condition as when installed. HAROLD W. STEELE.
Ass't. Electrician,
Naumkeag Steam Cotton Co.,
Salem, Mass.

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Replying to W. P. B., this type of conductor has found its greatest use in street lighting service where the lighting standards are located in the grassy portion of the parking between the curb and the sidewalk. It is also in extensive use in city parks where it is buried directly under the sodding, from 18 in. to 30 in. deep. Further, it has been widely used in England, and to a limited extent in this country, for general distribution work. For general service, however, its use is limited to districts where it is not expected that the load will increase materially. A large increase in the load makes it necessary either to lay new cable or dig up and replace the old one.

A standard line of junction boxes and fittings is available for this type of cable, and while its use in this country dates back not much beyond ten years, it is increasing in popularity. No particularly severe troubles have been encountered with it in service and when the lead sheath is protected with a jute covering, then with a double steel tape and another covering of jute over the tape, the life of the cable would appear to be indefinite. I know of some installations under railroad tracks that have been in service for over nine years, without a single case of trouble. C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson and Porter,
Springdale, Pa.

* * * *

I would like to give W. P. B. an idea of our experiences with armored steel cable, lead-covered and jute-wrapped outside the steel bands. The company with which I am now associated uses as much or more steel-armored cable than any other company in the South. We operate about 12 slopes and several drifts. All mines are supplied with alternating current. The tipple equipment fans and pumps are driven by 2,300- or 550-volt a.c. motors. We have installed both armored and weatherproof cable; the latter is used only on the 550-volt circuits.

Potheads are only used on the power-house cables and on the 13,000-volt cir-

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cuit. Most of the cables are just cut the desired length, the armor stripped back, the ground insulation removed and the rope core cut out at the crotch of the three conductors. The lead sheath is rolled back, so as not to chafe conductor insulation. Then several layers of varnished cambric tape are woven in between and around the three conductors to form a sort of insulating cushion, and to keep the wires spread apart. This tape is covered with several layers of P. & B. waterproof tape, which is warmed with a blow torch when applied, and this is topped with a heavy coat of insulating paint. A cable so treated is waterproof for a reasonable length of time, but as the varnish ages and dries out, the moisture penetrates the cracks and will cause a breakdown to ground. These crotches or splices should be painted with a good insulating varnish ever so often, according to conditions under which they operate.

Another method that I have used for crotching cables is to use linen tape and dip it in boiling or hot paraffin wax, dipping every time a layer of tape is applied, and dipping the finished crotch several times to be sure of a heavy outside coating. The above method is simple and requires no great mechanical skill; almost any mechanic around the mines can make a simple and reliable cable repair with a little practice. But cables so treated must be inspected at regular intervals, or they will be a constant source of trouble; at each inspection we generally paint the joint or crotch.

If cables are put up with potheads and splices are sleeved over with a lead sleeve, they are subject to very little trouble, whether inside or outside the mines, but as cable splicing is, or has become, a trade in itself, there are not so many electricians who are able to do good cable splicing. Although almost any telephone man can give one pointers about cable splicing, and with a little practice and judgment a mechanic ought to be able to make a decent wiped joint.

I know of one large mining company which has several miles of 6,600-volt, three-conductor, steel-armored cable and some without lead or armor, but it is all laid in fiber duct on the trolley wire side of the mine track. They made their joints in junction boxes and the joints were coated with hot paraffin.

In one instance I dipped water off a joint in this cable with an iron bucket; the juice was on and we were afraid the joint might blow if the water were not removed. However, this was not so much of a gamble as one might think, because these joints are waterproof if correctly made and maintained.

Steel-armored cables should not be suspended in bore holes or shafts because their weight soon exceeds their safe strength and as the wires are woven around the core, they tend to flatten out; this crushes the intervening insulation, causing a breakdown. Cables can be supported by suitable clamps, on a messenger; one strand of tiller rope can also be used to tie it to messenger cable.

There is one objection to cables and it is this: when one cable on a system becomes grounded and does not blow a fuse or knock the breaker, all of the other weak cables or joints are subjected to a strain until the defective cable or part is removed. When one cable breaks down several more are likely to follow suit, if many are in operation. GRADY H. EMERSON.

Ass't. Chief Electrician,
Alabama Fuel & Iron Co.,
Acmar, Ala.

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Answering W. P. B., we have one 2,500-volt, three-conductor, lead-covered, wire-armored cable about 3,000 ft. long, which was installed in 1910. This cable has never given any trouble and megger insulation tests show it to be still in first-class condition. The cable was laid in a trench about 2 ft. deep and, as there was likely to be some later digging in the vicinity of the trench route, rough planking was placed over the cable before backfilling with the excavated earth. It was not expected that the planking would serve as a protection to the cable, but it was used simply to indicate to workmen uncovering it that they were close to the cable and should, therefore, use caution in further digging in order not to injure the cable.

This particular cable has 30 per cent Para rubber insulation, but manufacturers will make cable to any specifications required. The standard specifications of the Joint Rubber Insulation Committee may well serve as a guide in buying this class of cable, which has been so standardized as to be quite reliable. With proper care in manufacture and installation there is no reason why such a cable should not last as long as a plain, lead covered one in ducts.

Regarding the installation of this kind of cable, the methods to be followed will vary with the length to be installed, size of the cable (since this affects the unit weight), and with the character of the ground. For short lengths and small-size cable, ordinary methods of handling the cable may be used.

For longer lengths and larger sizes of cable which is to be run in open ground which may be traversed by a truck, the easiest method is to mount the reel on a truck and pay off the cable by hand into the trench as the truck proceeds along the trench route. If steep, hilly country or swampy ground is to be covered, over which a truck could not travel, the best way is to set the reel up at one end of the trench and place pieces of timber (preferably rounded pieces of sapling) across the trench at intervals of 20 ft. or so. If the trench route is passable for a team it is then fairly easy to have the team walk along the trench route, pulling the cable end along as they go and letting it ride on the timber cross-pieces. A good team can pull out 500 ft. of average-sized cable in this way. If the trench route is not passable to team or truck, a winch may be set up at intervals along the route and a lead line from this used to pull the cable into place.

It goes without saying that kinks in the cable should not be permitted under any circumstances and this, therefore, implies some previous experience and considerable care in the installation. Splicing should be done only by men experienced in this class of work, as cable failures usually occur at joints. An iron pipe sleeve long enough to reach from armor to armor should be threaded on the cable before splicing and then secured over the splice after it is made. Potheads of proven worth should be used at all cable ends. The pulling line used in laying the cable should be attached to the armor wires and not to the cable itself, which should be sealed to prevent the entrance of moisture.

Fort Worden, Wash. E. I. PEASE.

* * * *

Method of Removing Cores from Fan Motors—Will some reader tell me the best method and equipment to use for removing the cores from 10-in., 12-in., and 16-in. Westinghouse fan motors? I find it necessary to remove these cores from the drawn steel housing that encloses the motor so as to be able to make repairs on the connecting wires, which usually burn off very close to the housing. This connection cannot be made on the outside. These field cores fit so closely that it is almost impossible to remove them without injury to the windings with all the methods that I have tried so far.
Madisonville, Ky. E. F. L.

With reference to E. F. L.'s question on removing the cores from Westinghouse metal-frame fans, make a cylinder one and one-half times as long as the core is wide, with the inside diameter slightly larger than the outside diameter of the core. The outside diameter of the cylinder is not important, so long as the wall is as thick as the frame of the fan. Strip the fan down to the core and frame and slip the cylinder over the edge of the core, where the end bell comes off. Grasp the cylinder and core in both hands and hammer down on a solid block; the core will drop in the cylinder after a few blows.

The core may be put back into the frame by clamping the frame in a large vise and using a smaller cylinder held against the core for driving it into place.

Augusta, Ga. O. B. EVE.

* * * *

Referring to E. F. L.'s question, the best method I have found for removing Westinghouse stators from the frame is, first, to remove the casing from the oscillating housing or the swivel, in the case of a straight fan, which is generally held on by means of four screws.

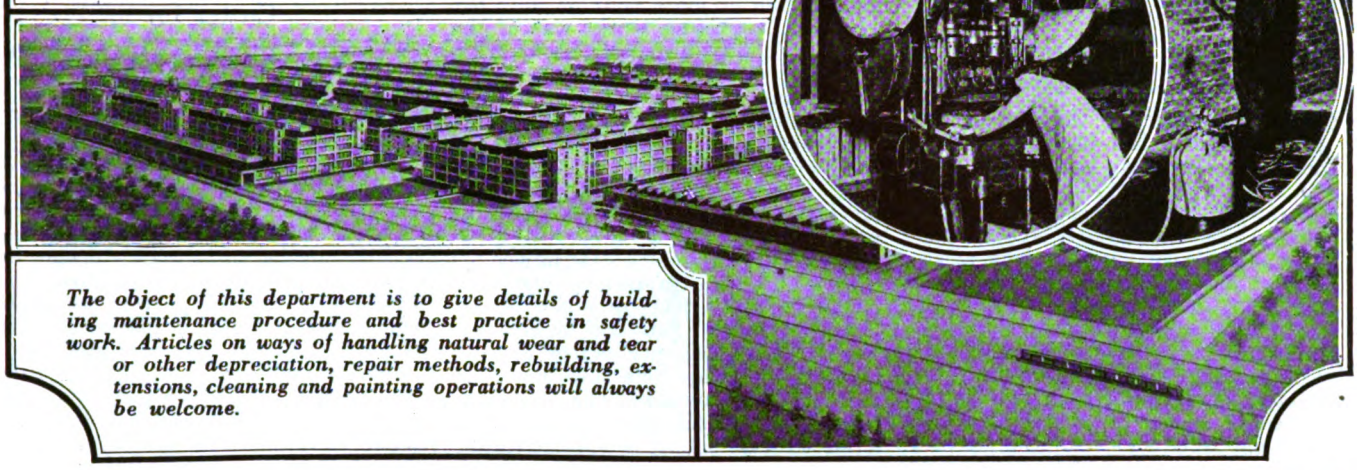
Then take off the fan end bonnet or end bell and with the motor held in a vise, saw through the outside housing between the screw holes in the bottom where the oscillating case or swivel was taken off. This will relieve the pressure on the laminations and the core can be removed quite easily. This saw cut will not show when the fan is reassembled and will not throw the bearings out of line or in any way affect the running of the motor.

There is a very good article by Carl G. Howard in the August issue of INDUSTRIAL ENGINEER, page 400, on removing cores. The method there described will work in most cases, but where the cores are as tight as in Westinghouse fans I have found it to be quite unsatisfactory.

Minneapolis, Minn. A. L. WALLOF.

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Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Putting an Acid Fume Discharge System Outside the Building

SOME time ago, the pickling department of our plant installed an exhaust system for removing the fumes from the pickling vats. These vats are 23 ft. long, 4 ft. wide and 2 ft. deep and are built in pairs, a pickling vat and a washing vat constituting a pair. Two pair of these vats, besides several smaller vats, are installed in this department which is in a room approximately 50 ft. long, 30 ft deep and 14 ft. high where it joins the shop proper, with a 2-ft. drop in a sloping roof.

The product is handled in and out of the vats by an overhead monorail system and the low headroom made it impossible to use a suction duct between a pickling and a washing vat. Also, this system would have left the several smaller vats in the room uncared for.

After a thorough study of this problem, we decided that a complete change of air was necessary in this room every 2 min. to maintain desirable working conditions. For this purpose an American No. 4 Sirocco fan with a capacity of 12,000 c.f.m. discharge was used; this is driven at 829 r.p.m. by a 15-hp. Westinghouse motor.

A hole 2 ft. wide and 35 ft. long was cut in the high side of the roof, which was suitably reinforced, and a triangular hood built over the opening on the outside, as shown in the accompanying illustration. This hood extended horizontally and was connected to the blower. All surfaces exposed to the fumes were given two coats of acid-proof paint. A penthouse was built over the blower and motor to protect them from the weather.

The low cost of installation, and the efficient results of this equipment make it highly satisfactory. However, we would have considered an addition to this system had our appropriation been sufficient to permit it. This would have consisted in running a ¾-in. air line around the large vats, and, I think, it would have been an improvement. This pipe was to be perforated with several ⅛-in. holes drilled at an angle of 45 deg. to the horizontal and connected to our high-pressure air line. When operating the vats, the plan was to crack a valve and so admit sufficient air through the perforated holes to break up the fumes and thus facilitate the action of the fan. This can still be added if the present exhaust system is not sufficient to maintain good working condition in the plant when it is closed up during the winter.

Chester, Pa. H. E. PILKINGTON.



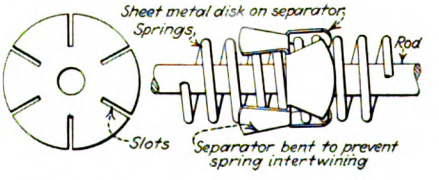
Because there was no room inside, this duct and blower were placed outside the building.

The overhead monorail system for handling material in and out of the pickling vats, prevented putting an exhaust duct over the vats. This outside exhaust duct, with sufficient capacity to change the air in the room every 2 min., provides the necessary ventilation.

How to Use Cut Disk as Separator Between Two Springs

IT IS not practicable to place two springs end to end without some form of separating disk between them, especially where the springs are wound to the same right or left pitch, as they will intertwine and reduce the effective length of spring.

On one job, in which a number of springs were used with a push rod as counterbalances for sashes, the problem of providing separators between the ends of the springs, was met with simple sheet iron disks made as shown in the attached sketch. These washer-shaped disks are about ½-in. to ¾-in. larger in diameter than the coil of the spring and have a hole punched in the center, to fit over the pull rods. The



Sheet-iron disks are slit as shown and tabs bent alternately up and down over the ends of the springs.

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disks were slotted about half-way radially and the tabs thus formed were alternately bent up and down to engage the spring ends as shown. These disks were easy to make and less expensive than punchings, cup-shaped drawings, or castings.

Washington, D. C. G. A. LUERS.

Construction of Metal Grating for Floor Openings

THE engineer or the master mechanic who has to build and install floors for smoke houses or for dry kilns, gratings to cover openings about buildings or coal holes along sidewalks, hatches over shafts, fire escape members and other similar places may, perhaps, appreciate having the experience of another from which to draw, instead of having to start from the beginning and work along unaided. The accompanying sketch shows the construction of a floor, which was put in the smoke house of a local packing plant, but it is typical of the class of gratings mentioned. This building is 10 ft. by 9 ft. 6 in. inside and had been used for other purposes, but remodeled for use in smoking hams and bacon. It is two stories high and the same types of floor and floor setting are used on both levels.

It is not safe to figure such floors on a passing or moving load basis only; there is always the possibility of storage upon the floors, even though the "work" may be intended to be hung from hooks or tracks. Also, a group of people may stand upon the floor, boxes may be dropped, or any of a dozen things happen that impose stresses far greater than the anticipated load of one person. To guard against such contingencies, we put four 4-in., 7½-lb. I-beams under each grille floor and set the ends 6 in. into the brick work, cemented them up when leveled and waited for them to set before laying the floor. The beams run at right angles to the slats of the grille, which are crosswise as one enters the door of this room.

For ease in handling and making, the floor was put up in three sections, each of which consists of 19 slats with the accompanying tie rods and spacers. The size of the sections of such grilles is regulated by the floor area, the support beneath, and the strength of the grille itself. In this particular case, light tie rods (⅜ in.) were used because the I-beams on 2-ft. 10-in. centers back up the slats and carry all the load at right angles to them. In other cases, the ends of the slats might rest upon a ledge or wall without other support. In such cases dependence for stiffness and against weaving must be placed on the rods and spacers; this calls for larger rods and larger spacers or separators. A ⅜-in. rod is so weakened by cutting a standard thread on it that life and limb should not be trusted to it, except possibly for short spans.

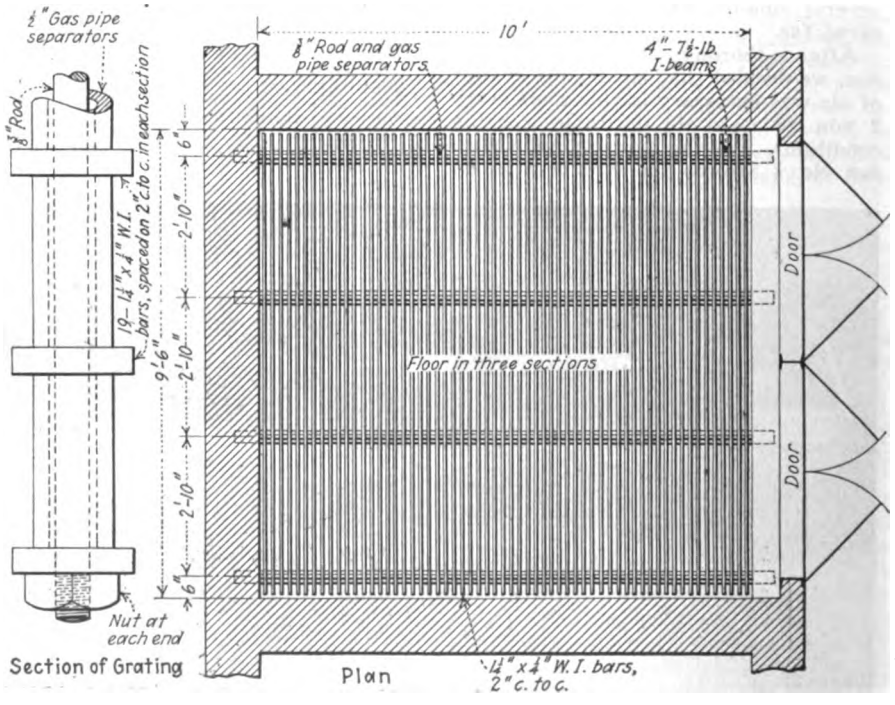
Grille floors are sometimes constructed by bending long flats in parallel runs spaced about 2 in. apart, thus getting two or more runs or slats out of a bar, according to the size of the space. This method costs about twice as much for labor and is no better than using separate pieces. Usually ¼-in. or ⅜-in. flats, 1¼ in. wide as a minimum, are employed for grilles; the former is desirable in most cases. The pipe separators should be nearly as large in diameter as the width of the flats.

The shop equipment determines the method used in processing the floor sections. Where lever or power shears are available the flats will be cut that way; if not, a number can be gripped in a vise at one time and sawed in the power or cold saw. The pipe separators can be cut more quickly in a lathe with a hollow spindle than by any other method. When a lathe is not available they can be sawed off. Their length need not be exact, but they should be uniform in order to produce a well appearing floor.

The slats may be turned out quickly. After cutting off, they have to be drilled for two or more (in this case four) tie rods. To do this, one slat is laid off and drilled; this is then clamped on top of a stack of others as a templet. When a number of floors are being made at one time, some of the drill-vise-jig devices might be used to advantage. Shops with facilities for punching would probably punch the holes instead of drilling them. Assembling is a job that even a boy can't do incorrectly.

Such gratings or grille floors could be more extensively used than they are. Many openings now closed with boards and trap doors would be better, safer and more fireproof with grille covers. Shops without the facilities for making grilles, or those which do not care to enter into this type of work, will find several grilles on the market which may be used.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.



The steel floor grating was strongly braced.

Although this floor grille was made for a smoke house, similar construction may be used in many other applications. Particular care must be taken to see that the grille is properly supported and has no opportunity to "weave" when men are working on it.

Cutter for Tearing Up Scrap Magnesia to Be Used Again

MOST maintenance men know that if old magnesia which has been removed from pipe lines can be utilized, it has considerable salvage value. However, in many cases it is thrown away. A very simple and inexpensive grinder can be made that will tear up this material, after it has been removed, into such shape that it can be molded again or used in plaster form to fill in corners and awkward spaces.

One type of machine which I have used is made from two pieces of 4-in. pipe with a number of holes drilled in them. Spikes are inserted from the inside of the pipes and project outward through these holes; the spikes are held in position by hollow, hardwood cores passing through the pipes. Short steel shafts fitted with pinions are fastened to the ends of the cores in the pipes, and the latter are then mounted in a suitable frame. The shafts are spaced in the frame so that the ends of the spikes are about ½ in. apart. A crank handle with a gear, which is placed so that it meshes with the pinions, drives the shafts through the pinions.

This cutter or grinder is placed in a trough-shaped frame and the scrap magnesia is fed into it. It is surprising how effectively this contrivance will rip up such material. An ingenious operating man could probably improve on such a device if sufficient quantities of material are available to make it worth while.

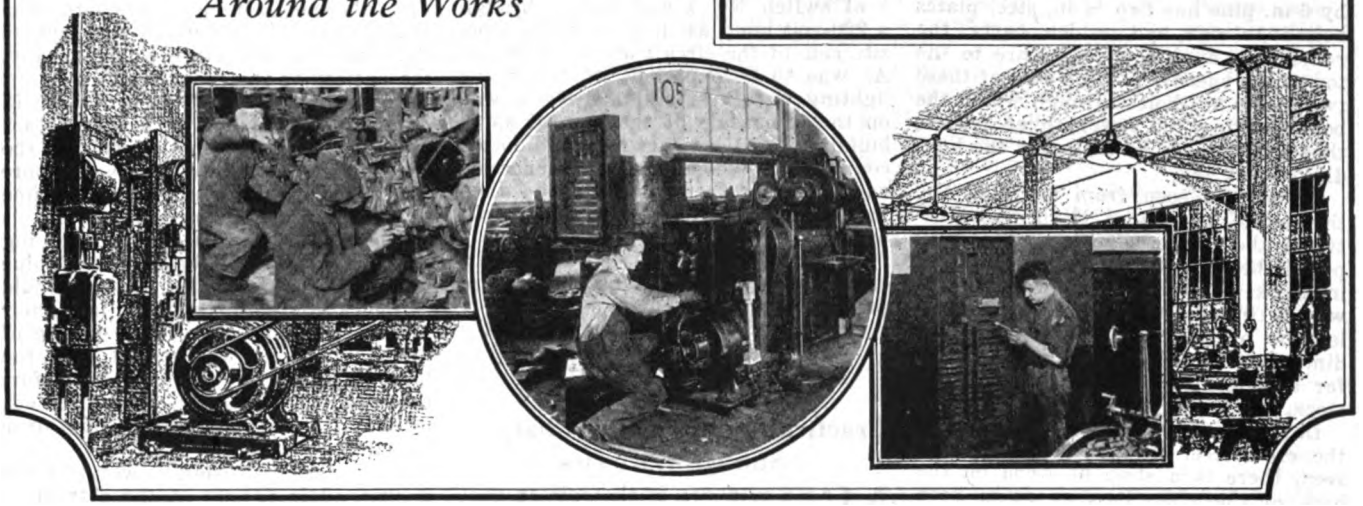
MAURICE C. COCKSHOTT.
Engineering Department,
Emsco Steel Products,
Los Angeles, Calif.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Better Product with Less Hazard by Using Electric Heat

IN THE manufacture of kegs, the finished staves are placed in a barrel machine which bends the staves into the form of the finished keg. A heavy steel ring is then placed at each end of the staves. It is necessary to heat the barrel thoroughly before these steel rings are removed and the hoops applied; otherwise, either the hoops would break or the staves would crack.

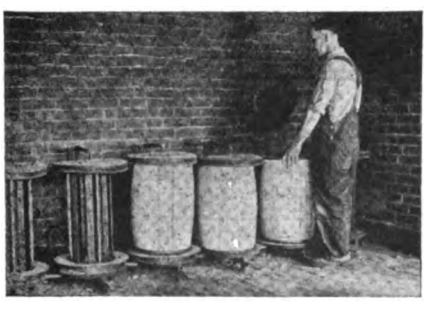
The heating elements of the heaters consist of standard Westinghouse space heaters, assembled on a circular frame. There are two series of heaters, each series consists of six heaters, and stands opposite a machine which assembles the staves in the steel rings.

The operator takes a barrel from the machine, raises the cover by means of a foot lever and sets the keg over the heater with the space heaters inside. The foot lever is then released and the cover drops. In a minute or two the keg is taken from the heater, ready for the hoops.

Before installing the electric outfit, open flame heaters were used, in which waste-wood was burned. Six of these heaters were set together in a large brick structure resembling an open fireplace. It was not only hot and disagreeable for the workmen, but there was considerable fire risk. After a disastrous fire in 1921, we decided to do away with unnecessary fire hazards, and the electric heaters were installed.

Since the installation of the electric heaters, there has been less breakage in manufacture, due to the fact that with electric heat the barrel appears to be heated uniformly throughout with rapid penetration of heat to the exterior of the barrels. And no barrels are lost by overheating nor do they catch fire. The cost of the installation has more than paid for itself by giving a better product, reducing fire risks and improving working conditions.

Spalding & Frost Co., Fremont, N. H. S. A. FROST.



Arrangement of electric space heaters which replaced a wood burning stove in a cooperage plant with considerable economy and other advantages.

Comment on "Maintenance of Large Motors in Steel Mills"

IN THE article by O. Needham on page 423 of the September issue, I noticed that the formula given for measuring insulation resistance with a voltmeter is as follows:

$R=[(V-v)\times r]\div V$

where R=the insulation resistance
r=the resistance of the voltmeter
V=the line voltage
v= the voltmeter reading

In the American Electricians' Handbook this formula is given in the following manner:

$$R=r\left(\frac{V}{v}-1\right)$$

As these formulas do not seem to be equivalent, I would like to know why there is such a great difference between them.

Jersey City, N. J. W. J. STERNAD.

* * *

There is a typographical error in the formula as printed on page 423. Correctly stated the formula should read:

$R=[(V-v)\times r]\div v$

This formula can be transposed to the same form as given in the American Electricians' Handbook as can be seen from the following equations:

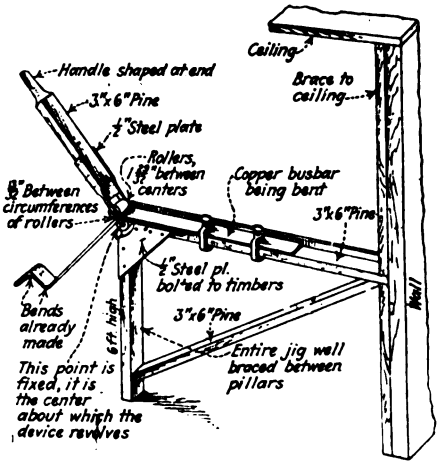
$$R=r\frac{(V-v)}{v}=r\left(\frac{V}{v}-\frac{v}{v}\right)=r\left(\frac{V}{v}-1\right)$$

In reality the two formulas are equivalent.—EDITORS.

Easily-Made Device for Bending Copper Busbar

THE method of bending copper busbars that is shown in the accompanying diagram is interesting in itself and may appeal to readers of INDUSTRIAL ENGINEER.

As can be seen in the accompanying diagram, the device consists of a 3-in. by 6-in. cross-member and a vertical upright of the same size, which are braced to the wall and floor. To reinforce the crosspiece and the upright, a ½-in. steel plate is bolted on each side of the timbers, as is shown in the diagram. In the corner of these two plates, a hole was drilled to receive a bolt carrying the roller over which the busbar is bent. In the diagram the plate is cut away so as to show the



This device can be set up at the place where the busbar is to be installed. The bender was used for bending bars ⅜ in. thick by 5 in. wide.

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roller behind it. There are two rollers, each of which is 1½ in. in diameter. These are made from steel shafting. A hole was drilled through the axis of the roller to receive the bolts holding them in place. A handle made of 3-in. by 6-in. pine has two ½-in. steel plates bolted to one end, which carry the roller that applies the pressure to the top of the busbar. At the ends of these two plates are holes through which the bolt carrying the lower roller passes, thus forming the bearings for the handle to work in.

As can be seen from the diagram, the rollers are placed 1⅛ in. apart between the inside surfaces. This will permit bending copper busbar stock ⅜ in. thick. The stock that was handled was ⅜ in. thick by 5 in. wide and in lengths of approximately 8 ft. The dimensions given on the diagram are for a bender capable of handling this stock.

In operation the busbar is clamped to the crosspiece, as shown. As can be seen, there is a strip of wood on the back of the crosspiece, so as to keep the busbar square while bending. The part of the busbar that is to be bent is placed between the rollers and then by pulling down on the handle a bend up to 90 deg. may be made.

Oakland, Cal. S. H. SAMUELS.

Method of Determining Lighting Circuit Connections

THE accompanying diagram shows the method that was used in finding the relative lighting circuit connections in two buildings, about 50 ft. apart, supplied with single-phase, three-wire service which was brought in through long outside conduit runs. Building No. 1 was connected first and contained a motor operating at 220 volts and one lighting circuit of 110 volts. Building No. 2 was similarly wired and connected later, with the intention of having its lighting load balance that of building No. 1.

When connecting building No. 2, the electrician took it for granted that the outer wires to the main switch came "side for side" from the transformer, as in building No. 1, and made his lighting circuit connections accordingly. It was decided later to install a motor in building No. 2 and since the transformer was barely large enough to carry the load, it was imperative to have the lighting loads balanced.

The conduits were high up on the buildings and since we had nothing but a short ladder we could not reach them. So we had to find some other way of testing the circuits. The outer sides of the switches were numbered *1* and *2* and in building No. 1 it was noticed that the lighting circuit was between the neutral and side *2*. The electrician when connecting building No. 2 put the lighting circuit between the neutral and side *1*, as shown by the dotted line, which seemed logical enough.

We had a length of No. 14 wire handy; so we connected one end to side *2* of switch No. 1 and tested through a 220-volt lamp as shown for the opposite side of the circuit at switch No. 2. As was to be expected, we found the lighting circuit in building No. 2 was on the same side of the neutral as in building No. 1, as shown by the dotted connection. We changed the connection as shown by the solid line and then found the loads to be practically balanced.

This method of testing out the circuits was very simple and easy to apply and served its purpose well.

HENRY MULFORD.

Patchogue Electric Light Co.,
Patchogue, N. Y.

One end of a length of wire was connected, in series with a 220-volt lamp, to one side of the main switch in building No. 1 and the opposite side of the circuit found in building No. 2 by touching the other end of the wire in turn to each pole of the switch.

Practical Pointers on Charging Storage Batteries

MANY men are of the opinion that there has been very little, if any improvement in the manufacture of storage batteries for a number of years. But the construction of the batteries has changed, and one of the proofs of this can be found in the way in which batteries are now being charged.

The old way was to charge at a constant current, and the writer can recall when he was instructed that the proper way to charge a battery was to keep the current constant from the beginning of the charge until it was nearly ended.

This was done by raising the voltage of the generator from which the batteries were being charged, as the current in the batteries increased and their voltage became higher; by charging through resistance and cutting out more and more of this as the charging continued; or by the use of end cells which were cut out as the current dropped off.

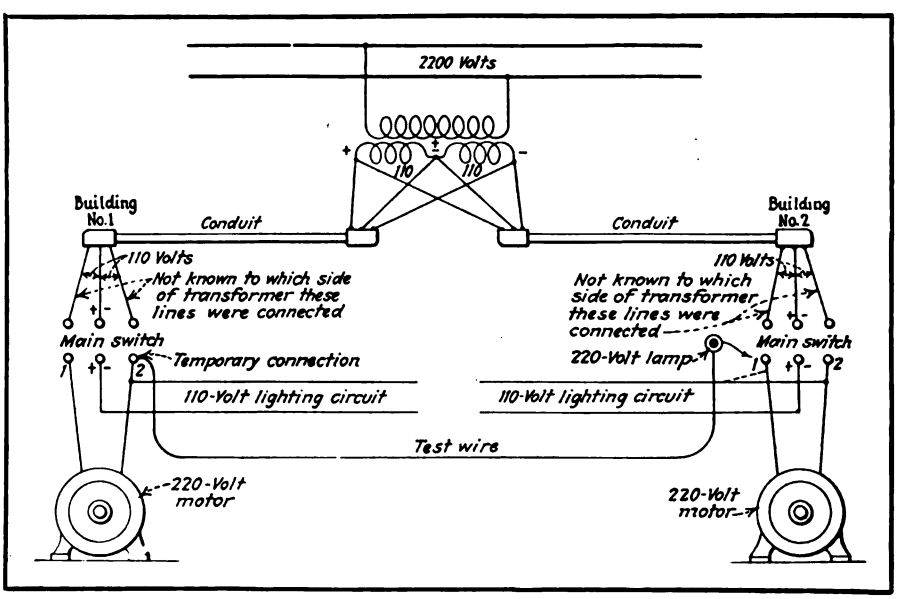
In those days it was believed that the best way to maintain a storage battery was to discharge it at a certain constant rate for a period of 8 hr., at which time the battery was supposed to be entirely discharged, or at least had been discharged as far as it was safe to go. Then the battery was put on charge and charged at the same constant rate for a period of 10 hr. The efficiency, in ampere-hours was considered to be about 80 per cent so that the 8-hr. discharge would exhaust the battery to the point where a 10-hr. charge would be required to restore it. After the 10-hr. charge at a constant rate it was thought best to continue the charge at a lower rate for several more hours, reducing the current from time to time in order to prevent gassing.

The reason for this care in charging and discharging the batteries was due principally to the fear that they would be badly injured, or at least have their life much reduced, by a higher rate of discharging. It was feared that the battery would be discharged too far; that the plates would become buckled; or that the active material would drop out of the plates.

In modern batteries, however, there is very little danger of these troubles occurring. Not only are the plates made better and stronger than the old ones, but separators are placed between the adjacent plates so that they cannot touch each other and become short-circuited even if there should be considerable distortion caused by buckling. There is much less chance of the active material dropping from the plates, and they are set up higher on longer feet so that more sediment can accumulate without the old danger of it rising so high as to short-circuit the plates.

On account of there being no fear of injuring the battery by charging faster than the old rate, a different method is now the generally accepted way of charging batteries. By this plan, instead of charging at a constant current and altering the voltage at the battery terminals so as to keep the current constant, the voltage is kept constant and the current is allowed to change. When the battery is first put on charge the current input is very high, but this soon slows down as the voltage of the battery rises.

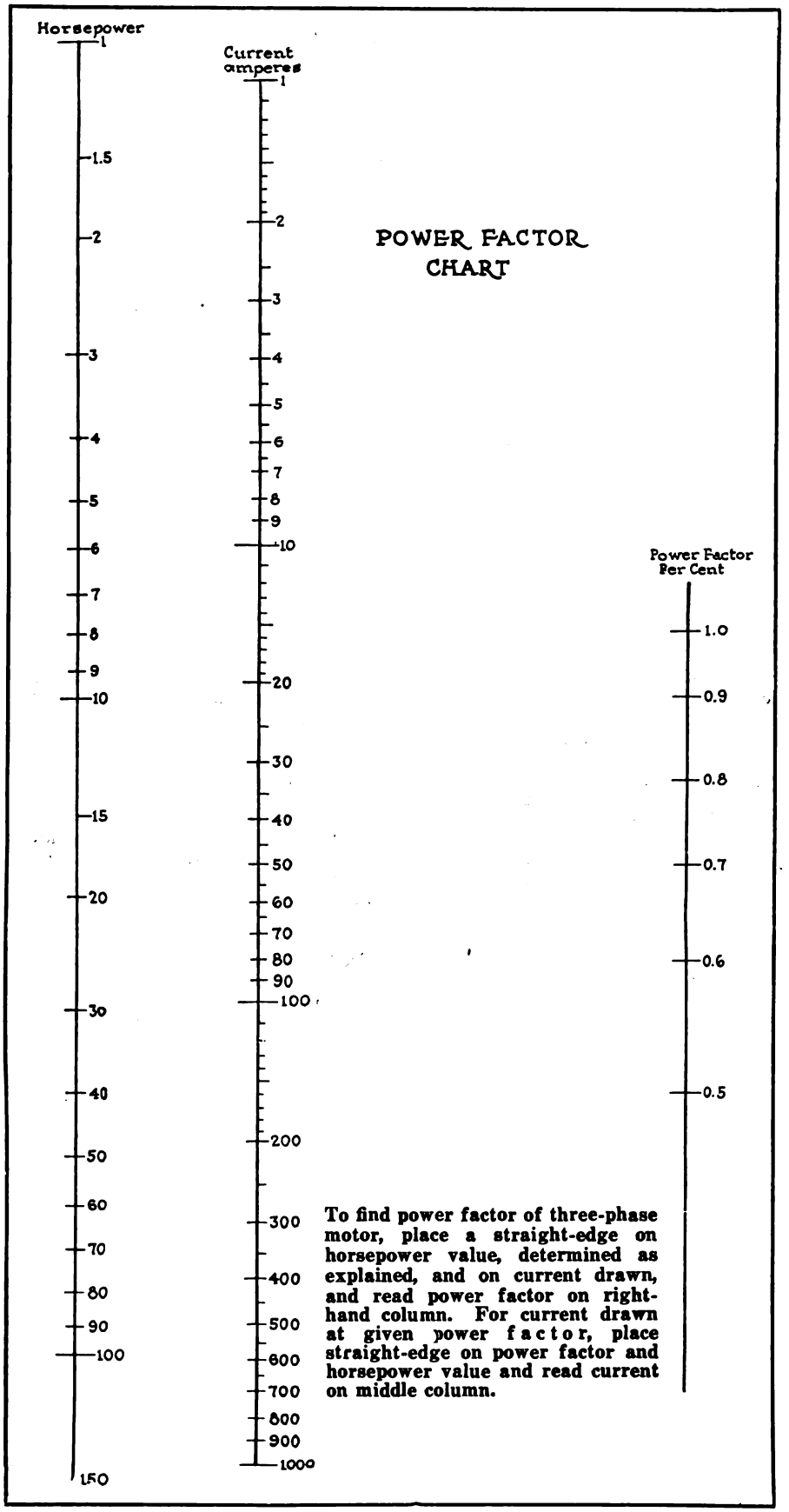
So long as the current is not so great as to overheat the conductors leading



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from the source of supply to the battery, or the terminal posts of the battery, the limiting amount of current can be considered as being that at which the battery begins to gas heavily, or else that which heats the electrolyte to a temperature of more than 110 deg. F.

If the battery is equipped with an ampere-hour meter set so as to show the number of ampere-hours that the battery has discharged, it is always safe to charge the battery at a rate which is not greater than the number of ampere-hours that have already been drawn from the battery, if the conductors and terminal posts will stand so high a charging rate.



As the voltage of the battery will increase as it is charged, there is no danger that the charging rate will be increased after the beginning of the charge unless the voltage of the supply circuit should also rise. Where that is constant, it is safe to say that the initial charging rate is not too high and then let the battery charge at that rate without having to watch the rate of charge closely One plan is to make the voltage of the charging circuit, at the battery terminals, equal to about 2.3 volts per cell of the battery being charged. At this rate the battery will become fully charged in a much shorter time than by the constant current method and the charge will automatically taper off to the proper finishing rate.

However, when a battery has been more or less completely discharged and the voltage correspondingly lowered, it will be found that such a high voltage applied to the terminals of the battery will give too high an initial charge. A safer way is to charge through a resistance which, although it will waste a little of the power passing through it, will limit the current in the beginning to a safe amount even if the battery should have been entirely discharged. On account of this resistance being in circuit, the voltage applied to the terminals of the battery and outside of the resistance should be equal to 2.45 volts, instead of 2.3 volts, per cell. This increase in the voltage will allow the battery to take a full charge, even though the resistance is there; while on the other hand, the resistance will insure that the charging rate will never be so high as to injure the battery or the conductors leading to it.

Westfield, N. J. G. H. McKELWAY.

Chart for Power Factor and Current of Three-Phase Motors

THE accompanying chart may be used to find either the power factor or the current of a three-phase, 220-volt induction motor. When using the chart to determine the full-load power factor, use the full-load current value stamped on the nameplate. For other than full-load values, use the corresponding horsepower values. Then, place a straight-edge so that it crosses the left-hand column at the proper horsepower and the middle column at the current drawn in amperes, and read the power factor on the right-hand column. To determine the current of a three-phase motor when the power factor and horsepower are known, place the straight-edge on the proper values in the right- and left-hand columns and read the current drawn on the middle column.

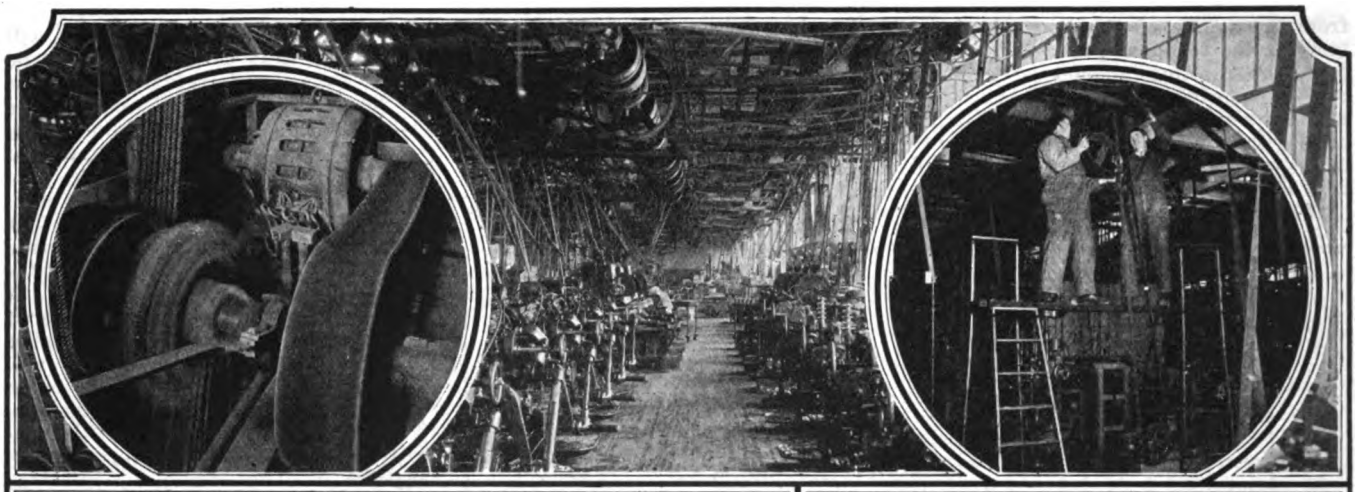
It should be noted that this chart may be used without corrections only for 220-volt motors. If it is desired to find the current for motors of other voltages the following corrections should be applied:

For 110 volts, multiply current by 2.
For 440 volts, divide current by 2.
For 550 volts divide by 2½.
For 1,100 volts, divide current by 5.
For 2,200 volts, divide current by 10.

CHAS. F. CAMERON.

Rock Springs, Wyo.

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Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Modernizing Sets of Old-Type Gear Reductions With Oil Circulating System

IN A plant where a number of sets of reduction gears of a somewhat old type were used, their economical and efficient lubrication was a serious problem, as no provision was made for the circulation and recovery of oil. An oiler poured a given amount of oil regularly into the gear casing and emptied a catch-pan, attached to the casing, which caught the excess oil as it passed through the gears. Sometimes he forgot to empty the pan so that the oil ran all over the floor, and was wasted. The used oil was filtered and re-used in other parts of the plant.

On account of the difficulty of getting at the gears they were often neglected and serious trouble sometimes resulted, which was due to the gears freezing from lack of lubrication and attention. In order to improve and modernize the method of lubrication at a minimum cost, a circulating system was installed as shown in the accompanying drawing. This was an immediate success, both from the maintenance viewpoint and because of a noticeable decrease in operating costs, through the elimination of the oiler and in the amount of oil used.

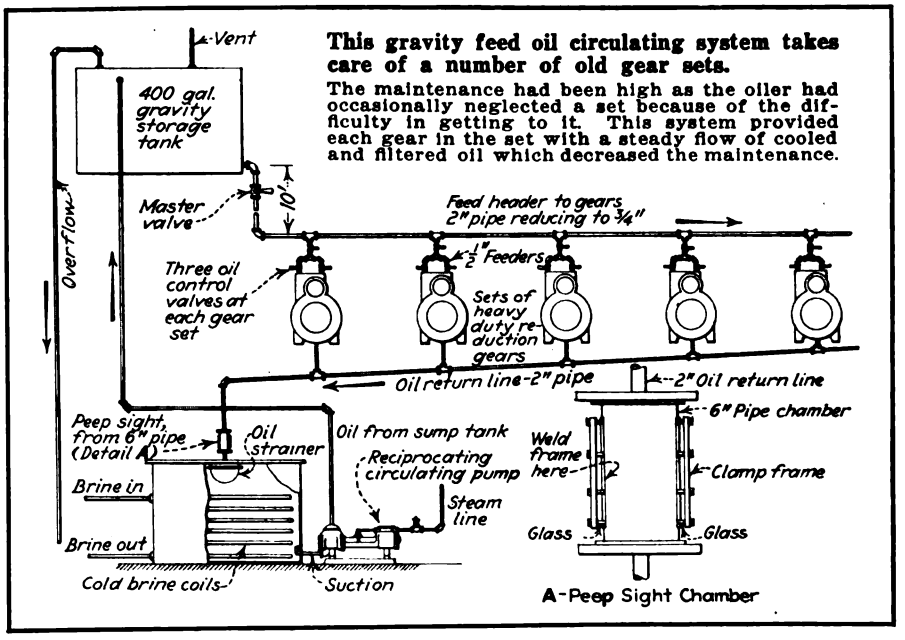
The 30-hp. reduction gears, giving a 20-to-1 ratio, which were connected through a pinion and gear to agitating paddles in tanks, were situated about 40 ft. above the floor. In order to get a gravity flow, it was necessary to elevate a 400-gal. storage tank about 10 ft. above the gears; fortunately the building was of sufficient height to permit this. A feed header nearly 200 ft. long was then run from the storage tank to the gears set farthest away. This header started with a 2-in. pipe and dropped by stages to a ¾-in. pipe.

From this header ½-in. feeder pipes, each with a master control valve, were run to each gear. These feeder pipes branched at the end through a tee so that the oil could be discharged into the two parts of the gear, with controlling valves in each of the separate lines. The oil drained from the gears flowed into a 2-in. return pipe which ran underneath the sets and sloped away from the furthest unit. Fortunately, the temperature of the building was hot enough all the time to prevent the oil from coagulating in the lines. This return line discharged into a sump tank on the ground floor. The returned oil was filtered through a strainer which consisted of a wire basket lined with flannel; the latter was detachable so that it could be cleaned.

Two small reciprocating pumps, that were not in use, were pressed into service to handle the oil from the sump to the gravity or storage tank. The pistons were grooved and fitted with a ring of babbitt which was cast and turned up. The pumps were hooked up so that one was always available as a spare in case of a breakdown.

At first some trouble was encountered in the adjustment of the pump speed. Because the pumps were of greater capacity than was necessary for this work they were run at such a slow speed that often shift men were under the impression that they should be running faster and speeded them up, with the result that the sump was pumped dry and the storage tank would overflow. This was overcome by reducing the size of the steam pipe to the pump, so that it was not possible to race the pump. In addition, a float valve was connected to control the steam valve of the pump. It was then possible to adjust the speed of the pump so that it would run for long periods without any attention beyond oiling.

A cold brine line was tapped and run through a coil of 1-in. pipe in the lower part of the sump tank to cool the oil. An overflow line from the overhead gravity tank was run into a receptacle



This gravity feed oil circulating system takes care of a number of old gear sets.

The maintenance had been high as the oiler had occasionally neglected a set because of the difficulty in getting to it. This system provided each gear in the set with a steady flow of cooled and filtered oil which decreased the maintenance.

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placed in a conspicuous place. The foreman on the shift watched this as it indicated whether any obstruction in the line prevented the oil from flowing out of the tank to the gears.

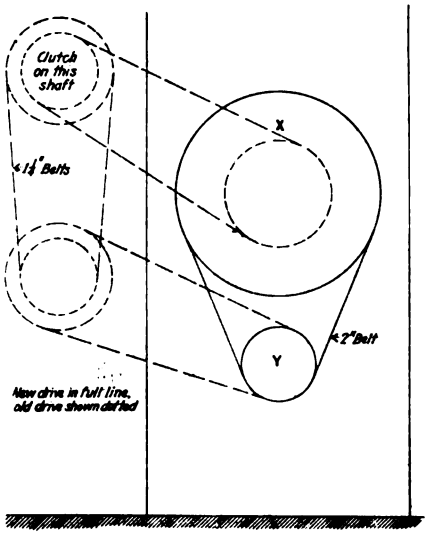
As the sump tank was a closed tank it was not possible to see the return flow from the main return header; so a peep chamber was made by running the line into a section of 6-in. pipe, with a piece cut out of two opposite sides, and a frame welded on with a piece of plate glass behind it and held in place by another frame and cap screws, as shown in the detail sketch. This was in line with a window in the daytime and a light at night so that the foreman could see the amount of oil being returned to the sump tank. As a result of this simple and inexpensive system, a cool, clean stream of lubricant was kept circulating through the gear units. This eliminated much heavy maintenance and increased the life and satisfactory operation of the gear units.

MAURICE C. COCKSHOTT.
Engineering Department,
Emsco Steel Products,
Los Angeles, Calif.

How Simple Changes in a Feed-Belt Drive Improved Operation

IN A specialty plant trouble was experienced on the drive for a Pratt & Whitney vertical surface grinder that was used only on one class of work. These machines come regularly with belt or motor drive and with two changes of feed to the table. This particular machine was belt driven, but had been equipped with a motor which drives through a chain; also, it was "plugged" so that the operator could use only the higher rate of feed. The change of feeds was made through a push rod connected to a clutch between two of the feed pulleys on one shaft.

This table feed required three 1¼-in. belts and six pulleys to obtain the one rate of feed; these belts transmitted power from the pulley on the first shaft, marked *Y*, in the illustration, and one on the shaft which runs directly to the feed mechanism, marked *X*. The machine was operated steadily all day and often at night and so the three belts required considerable attention. Also, due to the play in the parts controlling the clutch, it sometimes failed to feed.



Three belts, six pulleys and a clutch were replaced by two pulleys and one belt.

Because this grinder was used on only one class of work it was possible to rearrange the drive and make it more direct. The original arrangement is shown by dotted lines in the sketch above; the improved drive is shown by solid lines.

This trouble with the clutch occurred at rare enough intervals for its cause to be forgotten or overlooked and the trouble attributed to some symptom that the latest operator thought he had discovered. In that way the clutch was responsible, at least once, for a half-day's delay while the repairman went over the other rather complicated mechanism before it was discovered that less than a minute's work on the clutch would fix it.

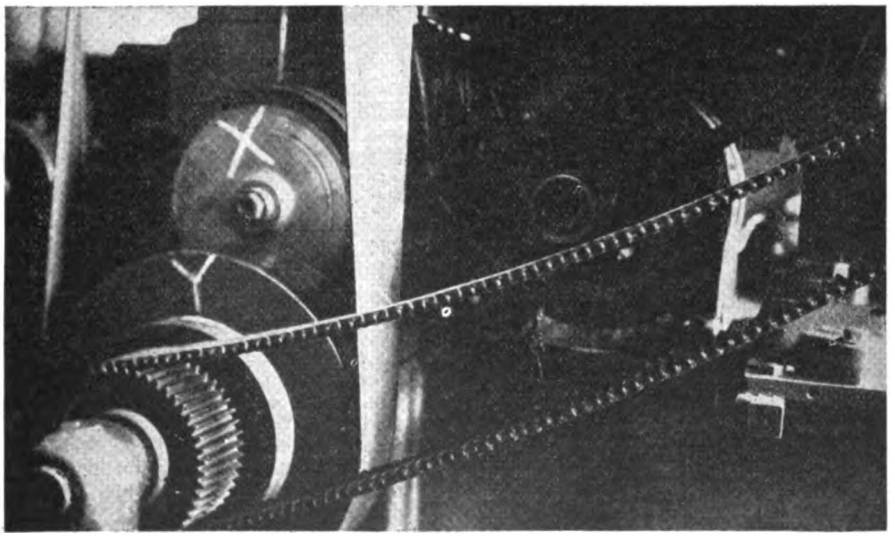
Finally, after one of these interruptions due to feed trouble, the master mechanic decided to alter the feed drive so that future trouble would be eliminated. As a result the machine now operates with two less feed belts and no clutch at all. The outline drawing shows the old and the new drives.

The diameter of the new driven pulley, *X*, is such that it turns at the same speed as its predecessor, although it is driven from the same small pulley, *Y*, directly beneath it. A 2-in. belt is now used which has nearly a half-circumference contact on the small pulley and its extra width gives it a longer wearing factor. The revised arrangement is much more simple and it is free from the former clutch trouble. The clutch was non-essential on the particular work done; however, to permit the use of a clutch was the only real excuse for the original triple-belt drive. The change more than paid for itself within a year.

A 5-hp., 1,800-r.p.m., alternating-current motor is mounted on the side of the machine pedestal and is connected to drive at the ratio of 3 to 2 by a Morse chain. Originally a step-cone pulley was belted from a countershaft, but this gave trouble; most of the lower step has been turned off to make room for the sprocket that takes its place. The driving side of the chain had to be the upper side, unfortunately, but in the seven years of its service it has never cost one cent in repairs or lost time.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

This illustration shows the drive after making the change.

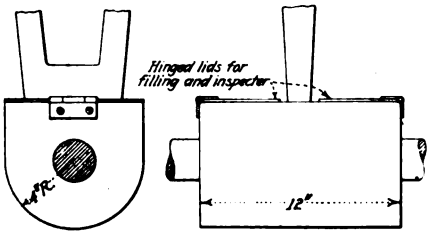


Oversized Drip Pan Prevents Oil Dripping

SHAFTING in textile mills are prolific sources of trouble from dripping and thrown oil. Even grease, where used, thins on the hottest days of summer, and runs like oil. This may spoil thousands of dollars' worth of fabric before it is corrected.

One large cotton goods mill has met the oil problem by completely enclosing the bearing of each hanger. For this it uses hundreds of pans of a standard size which can be fitted around the hanger on any size of shaft. The construction of this standard pan is shown in the accompanying sketch. This pan is more than a drip pan; it has sides, ends, and top and has a capacity of over a gallon of drippings. This oversize is a reserve against neglect and is large enough to enclose the bearings on the largest shafts.

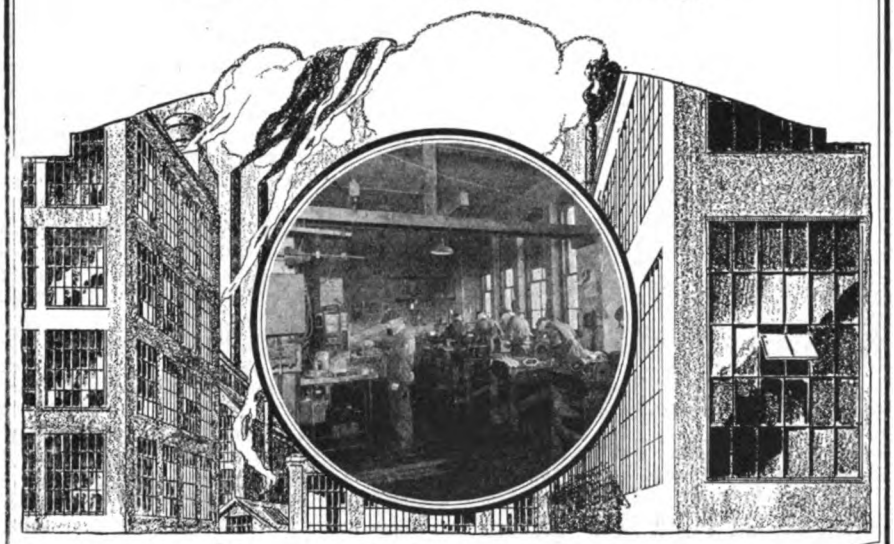
The pans are made of 18 gage galvanized sheet metal with locked and soldered joints. Lids at the top may be opened on each side for inspection, filling, emptying, and cleaning. These pans are held to the hangers by attachment brackets on the inside.



The construction of this oil drip pan is standardized so that it fits all hanger bearings.

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In the Repair Shop

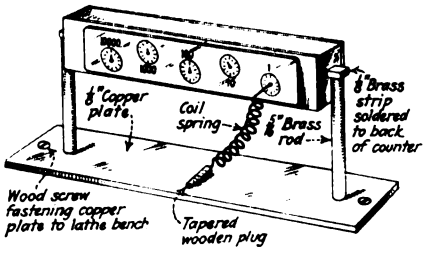


This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Easily-Made Device for Counting Turns When Winding Coils

IN THE April issue, page 204, Maurice M. Clement described a novel counter made from a speed indicator, for counting the turns on a coil. In our shop we use a counter made from the recording mechanism of an old gas meter and it works very well.

As will be seen from the illustration, a light coil spring was fastened to the post on which the unit dial hand of the meter was placed, and a wooden plug was fastened to the other end of the spring. A hole was drilled in the center of the spindle that holds the coil whose turns are to be counted and the plug was inserted in this hole. We riveted the counter to two brass rods and then cut a plate about 1½ in. wide and 6 in. long, from ⅛-in. copper. Two holes were drilled about 5 in. apart in this plate for the other ends of the rods to fit into, as shown The plate holds the counter rigid and by providing other plates at the different winding lathes we are able to use the same counter at all of them. The copper plates are fastened by screws to each lathe bench.



A coil spring is attached to the post carrying the unit hand on the dial mechanism of the gas meter. The other end of the spring is fastened to a wooden plug, which is inserted in the spindle of the winding lath.

The counter has dials which indicate units, tens, hundreds, thousands and ten thousands. By noting the reading when starting to wind a coil, it is an easy matter to determine at any time how many turns have been wound on by subtracting the first reading from the reading shown when stopped.

Peoria, Ill. GEO. D. RINGNESS.

Repairing Broken Drills by Use of Brass Sleeve

BREAKAGE of small drills is an annoying accident and if the stock is low or the drill is a special size, some delay may be occasioned. A broken drill can, however, be restored to service in a short time and at almost no expense, by making a brass sleeve into which the two broken ends of the drill can be soldered or sweated.

This sleeve should preferably be seamless and for this purpose seamless brass tubing, or solid rod with a drilled hole of the proper size to accommodate the broken drill, should be used. It is advisable to tin carefully the broken ends for a short distance. When tinning the ends, care must be taken not to overheat the drill and spoil the temper. If possible, the inside of the brass sleeve should also be tinned. When the broken ends of the drill are inserted in the sleeve, it is then an easy matter to sweat the ends to the sleeve by heating the latter carefully.

This same procedure has been used to prevent the breaking of new drills where the extended section from the jaws of the chuck makes it liable to fracture. The point where the break is most likely to occur is the junction of the flutes and the shank. A brass tube sweated or soldered on to a new drill is a very simple and effective reinforcement which is readily applied and overcomes to a marked extent the tendency to fracture.

Washington, D. C. G. A. LUERS.

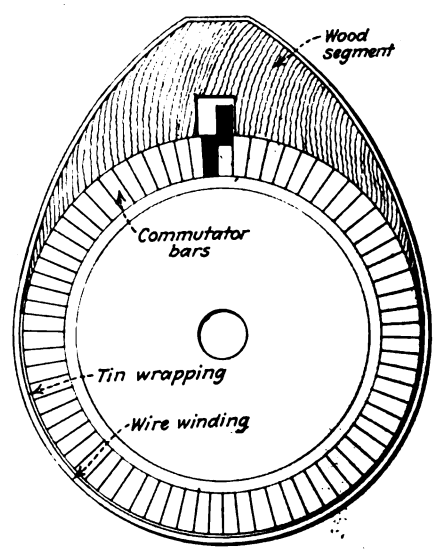
How to Make Simple Clamp for Replacing Commutator Bars

IN AN Eastern industrial plant, there are a number of Northern d.c. motors ranging from 5- to 15-hp. rating, that have been in use over 25 years. The plant repair man handles most of the maintenance and one of his occasional jobs is the replacing of commutator bars which have been tested and found shorted, and so have to be removed. It is only an occasional job, as has been said, and the man has very little equipment to work with—still he keeps the maintenance cost in that plant down to a very low figure.

He has an interesting way of keeping the commutator assembly in shape while replacing some of the bars. Before loosening the V-rings, he puts on a sort of clamp that prevents the bars from separating. This clamp is as efficient as it is simple, and consists of a piece of tin, some wire and a piece of wood, as shown in the illustration.

The wood block is cut from a piece of maple or oak somewhat over an inch in thickness, and is shaped in the form of a segment whose inner circle fits the commutator just half-way around. This segment is fastened to the commutator with wire and on the opposite half the piece of tin is laid double to prevent the wire from grooving the face of the commutator.

The wood segment has a slot cut in it, as shown, that is the width of one or two bars (whatever number have to come out) and deep enough to allow them to be lifted clear of their neighbors. This slot does not prevent the segment from holding down these neighboring bars, which is its sole pur-



A wooden block, cut in the form of a segment, and containing a slot the width of one or two bars, is fastened to the commutator by wrapping wire around it. A strip of tin keeps the bars not covered by the segment from being damaged.

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pose. For different commutator diameters, different segments are needed, but these are inexpensive to make and answer the purpose very well.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Layout of Lighting System and Equipment in Repair Shop

DEMANDS on a commercial repair shop are more varied and perhaps more severe than in the case of many industrial plant repair shops. The work coming to it ranges all the way from the repair of vacuum cleaner and other very small motors to rewinding the largest motors which it is practicable to transport for this purpose. For this reason close attention to details in laying out the equipment and the illuminating system is essential.

When we planned our new shop, the writer's past experience as an illuminating engineer naturally caused him to see to it that the lighting, both natural and artificial, was fully adequate from the standpoint of the latest developments in the lighting art. It is well known that our ideas have changed considerably in the past ten years regarding the amount of light which is proper for industrial operations. Evidence of the practical "dollars-and-cents" importance of both increase of quantity and an improvement in quality of illumination, has been rapidly piling up.

For daylight illumination, it was not feasible to provide windows on more than one side and in a small portion of another side, but at these places the maximum amount of window area obtainable was installed, as is shown in the illustration.

In a shop where armature winding is an important part of the work, good diffusion of light is important. That is, light must come from many directions. This is but another way of saying that freedom from shadows is essential. Again, as most of the winding work is on the stators of induction motors, the lighting should be such as to give a minimum of shadow in the stators in which the coils are being placed. In order to provide this good diffusion, the entire interior of the shop was given a coat of white paint, applied by an air brush. A small portable air brush outfit made by the Decora Manufacturing Co., Richmond, Calif., was used in this work. This air brush outfit is a part of the shop equipment, as it is used for cleaning and painting motors and also for finishing lighting fixtures in another department.

Painting the shop white was an important factor in getting well diffused light, both by night and by day, as the reflection from the ceiling and walls helps to eliminate annoying shadows.

As will be seen from the illustrations, the lighting equipment consists of bare bowl-enameled lamps. The omission of reflectors is not due to carelessness or a desire to save first cost, but to deliberate design. In a low-ceilinged shop of this kind, with walls and ceiling white, a much better quality of diffused illumination is obtained by omitting the reflectors. By omitting the reflectors, much of the light from the lamps strikes the ceilings and upper walls, from which it is reflected back onto the work. If opaque reflectors were used, the light at any one point on a winding bench would come largely from the lamp and reflector units which are of relatively small area compared to the reflecting surfaces offered by the upper walls and ceiling. The result would be much sharper shadows and less comfortable conditions as regards glare. As to the glare from the bare bowl-enameled lamps as compared to bowl-enameled lamps in steel reflectors, it is obvious that the brightest objects within the range of vision in either case are the tips or bowls of the lamp bulbs and these are, if anything, less bright on the bare lamps. If opaque reflectors were used, the ceiling would be considerably darkened and the contrast of the reflectors against the darker ceiling would offer an element of glare.

What has been said must not be taken as an argument against the use of reflectors. Their use is advisable in a large number of cases where, on account of high or dark-colored ceilings, it is not feasible to obtain much diffused reflection from the upper walls and ceiling, but it should be emphasized that the blind following of one common type of construction sometimes leads to unnecessary expense and inferior results.

As a general proposition for an armature shop, indirect lighting is the best. In the case of this shop, however, indirect lighting was not as necessary as in larger shops, and conditions were not so favorable as though the ceiling were plain and not cut up by joists. The conditions of work in the shop are not such that the light sources are within the range of vision steadily for any considerable length of time. The work benches, lathe, shears and coil winding machine are all so situated that the men do not face light sources when at work. The armature winding benches are in the center of the room, but when winding stators, a man's head is usually inclined so that the lamps are out of the field of vision. The room shown is about 16 ft. by 33 ft. and is lighted by eight 200-watt bowl-enameled lamps. The illumination on the working planes is from 15 to 18 foot-candles.

The equipment of the shop is shown in the illustration. Trucks can be backed in one end of the shop and motors picked up by the hoist which runs on an I-beam the length of the shop. The power driven machines consist of one lathe, one coil winding machine and an emery and buffing wheel.

The old-fashioned testing board with open knife switches and various exposed live contacts was eliminated in conformity with the safety regulations now in force in California. While exposed live parts are, of course, permitted in electrical testing shops and laboratories under the rules of the California Industrial Accident Commission, it was felt that the common testing operations in a motor repair shop did not necessarily call for more hazardous construction than used in any other industry.

The motor and testing circuits are controlled by the standard externally operated switches now required in all industrial plant work in California. For testing purposes, two- and three-pole receptacles of various capacities are provided and controlled by externally-operated switches.

We use a portable electric oven for baking coils, so that it can be moved to any convenient point in the room. Ordinarily, it is placed at one end in line with the hoist. It is connected by a three-conductor plug and cord to the three-phase power circuit. The oven measures 20 in. by 36 in. by 32 in. and has two Cutler-Hammer flat, air-heating, 600-watt elements.

President. J. R. CRAVATH.
Pioneer Electric Co.,
Richmond, Calif.



Bare, bowl-enameled, 200-watt lamps furnish the light in this shop. Note the enclosed, externally-operated switches on the testing board at the right.

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Industrial Uses of Structural Slate

(*Continued from page 535*)

the pressure when the drill is about to break through, to prevent a large scale from breaking away at the back. Whenever possible it is well to finish a hole by drilling in from the back as soon as the point gets through, as doing so prevents pieces breaking out.

Another use of slate is for special table tops, as in tanneries, for making tanks and vats for dye works, and tanneries, and so on. The particular advantages of slate as a material for these purposes are that it is non-absorptive, is not affected by the liquors, and also because it has a very low co-efficient of expansion, so that the joints do not work loose and break the cement which fastens the slabs together, as would be the case if the material expanded and contracted with changes of temperature. Slate is also commonly used for the tops of work tables used in the manufacture of candy, because the candy does not stick to the surface. Also, the surface can be easily cleaned or scraped and will remain smooth and even.

Editor's Note: Acknowledgement is made to the Structural State Co., Pen Argyl, Pa., for the photographs and information used in this article.

Visual Record for Motor Failures

(*Continued from page 518*)

check on the work of each of his maintenance foremen. The foreman knows this and consequently does his best to keep the tabs off his cards.

When a red tab appears on a card an investigation is made at once. Possibly the record on the card may show that bearing or oil trouble is the cause of the failures. In this case roller bearings are substituted for the sleeve bearings. In some cases it is necessary to take a load test on the motor by means of a graphic meter to determine what steps should be taken to eliminate the cause of the failures.

Since the system is easily understood and can be quickly grasped by anyone, it provides a good indicator by which the electrical superintendent can acquaint the plant manager with conditions in the electrical department. The necessity for new or improved power-drive equipment, more maintenance men, and the like, can be quickly verified by the graphic record shown by the system.

The advantages of this system may be summed up in the following:

(1) It enables the electrical superintendent to keep his hand on the pulse of his department. His attention is quickly attracted to the troublesome motors of the 3,000 under his care and steps can be taken to eradicate the trouble at once.

(2) Since the cards are filed by divisions, the electrical superintendent knows exactly what foreman to hold responsible for an undue number of failures. This acts as an incentive to the foreman to make a good showing.

(3) The system provides the electrical superintendent with a way of quickly showing his superior what the operating conditions are in his department, and will help to justify his request for more or better equipment, or more men.

Groundwork Before Erecting Lineshaft

(*Continued from page 523*)

to the concrete ceiling. For this purpose we use Brohard expanded shells. We have found that ⅝-in. bolts with the proper size of expanded shell will hold any footing except possibly for the larger sizes of shafts, which are seldom supported from the ceiling. To install these, holes are drilled into the ceiling, the shells driven into place and then the plank footing is attached by screwing up the bolts, which expands the shell in the concrete and gives a firm grip. A hole 4 in. deep with the proper size shell to take a ⅝-bolt is satisfactory.

Figs. 5 and 8 show an installation of a shaft on a concrete ceiling in a paint mill. The same method was used to hold up an I-beam for a monorail.

Whenever a building is wired and the power is available we use a Syntron electric hammer for drilling into the concrete. If power is not available, a man with a hammer and a star drill does the work. Sometimes it is necessary to drill holes entirely through the concrete, countersink the bolt heads, and patch up the floor.

A concrete ceiling probably furnishes the most satisfactory foundation for supporting a lineshaft as it transmits comparatively little vibration through from the floor above. Also, the deflection is comparatively slight. With these two factors eliminated the shaft is not likely to get out of alignment easily. However, it is always good practice to go over a shaft and check up the alignment after it has been in operation a short time and at frequent periods later.

There is still another problem of installation which occasionally comes up and is usually not easy to solve. A recent case of this kind was met in extending a lineshaft down through the center of a room with a high ceiling where there was nothing upon which to support the shaft hangers or footings. A few special columns consisting of extra-heavy 6-in. H-beams were erected by sinking one end in the concrete floor and fastening the other to the ceiling construction. Two parallel lines of extra-heavy, 7-in. ship channels were bolted crosswise to these H-beams. Wall brackets were used which had special projections or feet cast on them to fit into the two channels. Pillow blocks on the wall bracket support the shaft.

Sufficient allowance, however, had not been made for the severe service under which it operated and also more machines were added to the line than had been considered at first. As a result the shaft was too small and vibrated due to the high speed at which it operated and the "whip" which was transmitted back to it from the centrifugal machines which it drives. This was overcome by inserting additional brackets and pillow blocks midway between those already installed. These support the shaft on 4-ft. spacing instead of the standard 8-ft. spacing, but would not have been necessary if a slightly larger diameter shaft had been specified by the user. However, this was the first installation of such a large battery of centrifugal machines and the effect of the whip was unknown. This is an SKF ball-bearing installation operating at 600 r.p.m.

As mentioned at the beginning of this article, experience is a very important factor in lineshaft installation work. It is quite difficult, in some cases, to tell just exactly how a special installation will stand up until it is tried out.

EDITORS NOTE: All of the illustrations shown in connection with this article are of installations made under the supervision of Mr. Trimm in his work as millwright superintendent for the Chicago Pulley & Shafting Co.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Locomotive for Industrial Service—Book 250 is a 56-page catalog of trolley, storage battery, third rail, combination battery and trolley, and combination battery and third rail electric locomotives for industrial service. This book is well illustrated with a large variety of installations as well as a detailed description of the various types of units.—Goodman Mfg. Co., 4840 Halsted St., Chicago, Ill.

Flexible Couplings—Circulars announce a new flexible coupling known as the Sykes Universal shaft coupling. This consists of hubs fitted on the shaft with lugs projecting outward and a sleeve cast in halves with internal lugs fitted over this. Connection between the two is made by balls resting in races or grooves formed in these lugs. Claim is made that this coupling will take care of a limit of angularity of 5 deg. and a limit of offset of 4 per cent of the maximum bore. This coupling is at present manufactured in shaft sizes from ¾ in. to 8 in.—Farrell Foundry & Machine Co., Buffalo, N. Y.

Charging Plugs and Receptacles—A 72-page Bulletin, 38, under the above title covers the line of Anderson single-pole, double-pole, and three-pole battery charging plugs and receptacles for use in the charging of storage batteries for a wide range of commercial and industrial purposes.—Albert & J. M. Anderson Mfg. Co., 289-305 A St., Boston, Mass.

Tapered Roller Bearings — Announcement is made of an improvement and refinement in the design of the roll and in the shape of the Timken tapered roller bearing.—The Timken Roller Bearing Co., Canton, Ohio.

Portable Blower—A circular describes the new Sturtevant Big Midget portable blower, which is designed to be used for blowing dust out of motors, generators and all kinds of machinery. This blower is held in the hand and the blast directed through a nozzle; it is also furnished as a stationary unit.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Polyphase Transformer Test Connection Diagrams—Pocket-sized Bulletin 2048, under the above title, shows diagrams of test connections to be used on Pittsburgh polyphase transformers. — Pittsburgh Transformer Co., Pittsburgh, Pa.

Recording Pyrometers—A circular describes the Brown new design, single and duplex (two-record) recording pyrometers, multiple-record recorders, which can be arranged to make from one to six simultaneous records in distinctive colors on the same chart, and the multiple-duplex recorder, which will make from two to six simultaneous records on each half of a duplex chart.—The Brown Instrument Co., Wayne & Windrim Aves., Philadelphia, Pa.

Carbon Brushes—Catalog 7 illustrates, describes and prices the various types of carbon brushes for generators, motors and all stationary machines. The different shunt connections are listed according to capacity and priced separately.—Le Valley Vitae Carbon Brush Co., 3608 Grand Central Terminal, New York City.

Magnetic Clutches—Publication P-11 devotes 16 pages to illustrations and descriptions of many new uses of magnetic clutches on synchronous motor drives, particularly where the starting duty is severe, as in the cement, flour, paper and steel mill industries. — The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Conduit Fittings—A 21½-in.x32¾-in. wall hanger, which is attractively printed in colors, illustrates the various types of Unitlets—steel conduit fittings.—Appleton Electric Co., 1718 Wellington Ave., Chicago, Ill.

Welding Rods—A 28-page, pocket-size book entitled, "Properties of Steel Filler Rods for Gas and Electric Welding," discusses the properties of iron and steel filler rods and the effect of these properties, or the lack of them, upon the welding. The different types of Weldite rods, their specifications, analysis, and the types of work they are to be used on, are also included.—Chicago Steel & Wire Co., 103rd St. and Torrence Ave., Chicago, Ill.

Flexible Power Unit—A circular describes the Superba electric flexible power unit which consists of a motor driving a flexible shaft which operates scratch brushes, grinders, buffers, drills and other types of light revolving apparatus. — Sirianni & Trumbettas Mfg. Co., 6-8-10 Brown St., Carbondale, Pa.

Capacitors—A 24-page bulletin GEA-77 describes the value of capacitors for power factor correction, gives details as to their operation, location, and so on, and includes a number of illustrations in the form of charts, diagrams, tables and photographs of installations.—General Electric Co., Schenectady, N. Y.

Paint for Galvanized Iron—A folder describes Galvanum paint which is intended to be applied directly to galvanized iron without the previous use of an acid wash or primer. This paint is made in all colors, including black and white. Other special paints for specific industrial purposes are also listed.—Goheen Corp. of New Jersey, Newark, N. J.

Industrial Electric Heating Equipment—An 8-page catalog illustrates and describes a variety of special and standard electrical heating units for heating water and other liquids and compounds, air heaters, ovens and special heaters. Special attention is called to an electric pipe heater which can be mounted on pipes to keep them from freezing in cold weather.—Hynes & Cox Electric Corp., 406 N. Pearl St., Albany, N. Y.

Electric Hoists—A 28-page catalog illustrates and describes the constructions as well as numerous applications of the Low-Hed electric hoist, which is so constructed as to require only a small amount of head room below the monorail or other support.—American Engineering Co., Philadelphia, Pa.

Safety Ladders and Scaffolds—Circulars give the prices of and illustrate a line of safety extension ladders which can be used for industrial painting, millwrighting, and other miscellaneous industrial jobs. Bulletin 56 describes the Junior safety scaffold which is supported by steel wire ropes for painting, tuck pointing and other maintenance or repair work on the outside of buildings.—The Patent Scaffold Co., 1420-44 Center St., Chicago, Ill.

Standardized Bus Supports and Outdoor Substations—Announcement is made of a new net price list on standardized outdoor substations. A 38-page bulletin, 31-B, contains 119 illustrations giving detailed information on high-tension bus supports for voltages up to and including 120 kv. These supports are of standardized unit type with 21,000 combinations for standard, heavy-duty and extra heavy-duty service and are adjustable at top and bottom.—Delta-Star Electric Co., 2400 Fulton St., Chicago, Ill.

Speed Reducers—Bulletin 10-25 illustrates, describes briefly, and shows a few installations of the latest types of Philadelphia worm gear and spur gear reducers.—Philadelphia Gear Works, Richmond and Tioga Sts., Philadelphia, Pa.

Portable Carbide Lights—A booklet entitled "The Milburn Light" illustrates and describes the various types of portable and semi-portable carbide lights for lighting yards, mines, quarries and so on for night construction or other outdoor night work.—The Alexander Milburn Co., Baltimore, Md.

Underground Cable Boxes—Bulletin 25 describes and illustrates a line of underground cable boxes for use in manholes or handholes, for interconnecting, sectionalizing, fusing or plain splicing of underground electric cables.—G. & W. Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Ball Bearing Motors—Bulletin 25 describes the various types of Baldor electric motors, which are made in capacities of ½ to 10-hp., squirrel cage, polyphase; 1/6 to 5 hp., repulsion-induction, single phase; and 1/6 to 2 hp., direct current. Specifications and special applications are also given.—Baldor Electric Co., 4351-55 Duncan Ave., St. Louis, Mo.

Distant Dial Meters—Bulletin 69 describes the Sangamo distant dial meter which is used with watt-hour meters for duplicating at a convenient location the reading of the meter

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register, for totalizing the revolutions or strokes of engines, generators or other machines, or for summing on a single dial the total registration of a group of watt-hour meters. These distant dial meters are made in two types, for operation on direct current and on alternating current.—Sangamo Electric Co., Springfield, Ill.

Automatic Control of Planers Direct Connected to Motors—Publication C-14 bearing the above title, gives the advantages of such control equipment, describes the principal parts of the equipment, its operation and gives details concerning it.—Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Meter Service Devices—A circular folder describes the ease of installation of the Noark service system for entrance meters.—The Johns-Pratt Co., Hartford, Conn.

High-Speed Induction Motors and Frequency Changers—A 27-page, paper-bound bulletin 41521-B, bearing the above title, is well illustrated with photographs, diagrams and tables and presents a complete line of motors, alternators and frequency changers adaptable for application on modern, high-speed woodworking machines and other forms of machine tools requiring high-speed drives.—General Electric Co., Schenectady, N. Y.

Twin-Type Graphic Meter—Bulletin 425 describes a twin-type graphic meter which is provided with two charts so that any two items may be recorded simultaneously. These can be furnished in any combination of ammeter, voltmeter, wattmeter, kva.-meter, power factor meter, frequency meter, speed, pressure or vacuum recorder, condenser meter or service recorder and the two units can be alike or different. The two charts are driven by one chart-driving mechanism so that the record is made simultaneously of the two quantities.—The Esterline-Angus Co., Indianapolis, Ind.

Magnetic Counter—A circular describes magnetic counters which are operated by electromagnets and used under conditions where it is desirable that the counter be placed at some distance from the machine on which the count is to be taken. In this way a number of counters can be grouped together in a central or other convenient place. This counter is operated by direct current only.—The Veeder Mfg. Co., Hartford, Conn.

Panelboard Practice—A 48-page catalog describes the Superior switchboards for power and lighting, panelboards and cabinets for lighting and feeder distribution panels of dead or live front types. Diagrams, prices and applications are shown.—The Superior Switchboard & Devices Co., Canton, Ohio.

Expulsion Type Fusible Primary Cutout—Circular 65120 describes the Type E, Form A, Catalog No. 260-277, 100-amp., 7,500-volt fusible primary cutout.—General Electric Co., Schenectady, N. Y.

Roofing Reference Series—A series of five booklets contains architects and engineers construction service and design information on Barrett built-up roofs under the following five headings: I, Flat Roof Specifications; II, Steep Roof Specifications; III, Roof Flashing System; IV, Roof Drainage System; V, Dampproofing and Waterproofing. Each of these contain about 36 pages and are illustrated with drawings which give information to those interested in building or re-building roofs.—The Barrett Co., 40 Rector St., New York City.

Electrical Conduit—A folder entitled, "Facts Concerning Electrical Conduit," discusses the qualities required in good electrical conduit and describes the qualifications of Buckeye conduit and Realflex flexible steel armor cable.—The Youngstown Sheet & Tube Co., Youngstown, Ohio.

Rotary Shears—Catalog 60 describes the different types and sizes of rotary shares which are made to handle all gages of sheet metal up to and including 1 in. sheet steel. These are made in seven sizes. Shears for the lighter gages of metal may be used in many sheet metal shops of industrial plants for making safeguards, ventilating ducts and other miscellaneous plant work.—The Quickwork Co., St. Marys, Ohio.

Power Transmission Equipment—A new catalog under the above heading describes the Rex set collars and Cinch (compression) couplings for line-shafts, pillow blocks, journal bearings, post boxes, shaft hangers, extra heavy duty takeups, square or spiral jaw clutches, sprockets and chains.—Chain Belt Co., Milwaukee, Wis.

Flexible Couplings—A folder illustrates and gives dimensions and prices of five types of flexible couplings which Foote Bros. recommend and sell for use in connection with I.X.L. speed reducer units.—Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill.

Welding Electrodes—A 16-page booklet under the above title describes the characteristics and application of the three types of General Electric electrodes, designated as Types A, B and C, for use on cast iron, steel and on overhead welding. Brief instructions are given covering the use of each type.—General Electric Co., Schenectady, N. Y.

Electric Hoists—Form 118 illustrates and describes the Type R Roeper electric hoist which is made in capacities ranging from 500 to 6,000 lb.—Roeper Crane & Hoist Works, Inc., 1720-1738 N. 10th St., Reading, Pa.

Pressure Regulators—Bulletin 1033-B describes the E. C. & M. automatic pressure regulator which is used with motor-driven pressure systems for automatically regulating the pressure of water, air or other liquids or gases. Cushion tanks to take care of fluctuating pressure are also described.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Friction Clutch—A circular describes the Hilliard friction clutches and cut-off couplings which are made for both high- and low-speed operation. The pressure is applied through a rack and gear worm-thread movement.—The Hilliard Clutch & Machinery Co., Elmira, N. Y.

Electric Glue Pot—A circular describes the Red Crown glue pot with a snap action thermostat which automatically maintains the contents at the correct temperature and helps to eliminate fire risk. This pot is made in 1-qt., 2-qt., and 4-qt. sizes, for 110 and 220 volts. Other electrically-heated pots for melting other materials, such as lead, babbitt, pitch, wax, and so on, are also listed.—Hynes & Cox Electric Corp., 406 N. Pearl St., Albany, N. Y.

Synchronous Timer—Circular 67781, Class 16, describes the construction and operation of the Type MF-2 synchronous timer for indicating the time in which a device, such as a relay, performs an operation that includes the opening and closing of an electrical contact.—General Electric Co., Schenectady, N. Y.

Distribution Apparatus—A catalog describes the dead-front and live-front switchboards, panelboard switches and other special equipment, as well as steel cabinets, pull boxes, battery-charging rheostats and so on, manufactured by this company.—The Leonard Electric Mfg. Co., 3907 Perkins Ave., Cleveland, Ohio.

Stainless Steel—A 20-page booklet entitled "Stainless in Industry" explains the characteristics of stainless steel and shows many of the different possibilities for its use in various lines of industry.—The American Stainless Steel Co., Commonwealth Bldg., Pittsburgh, Pa.

Valve Control—Bulletin 103-29-B describes the Cory-Recony valve control units which permit of remote control through a separate power panel in which all circuits are opened and closed. Electrical braking permits seating with full power. This control is designed for use on 2- to 60-in. valves under varying pressure and temperature conditions.—Chas. Cory & Son, Inc., 183-7 Varick St., New York City.

Portable Saw—A folder describes the South Bend portable woodworker, Model A-25, which is a motor-driven circular saw mounted on a stand with casters to make it portable. A ¾-hp. motor drives an 8-in. crosscut or rip saw. An exhaust fan and bag to collect the sawdust make it possible to use this machine in places where dust and dirt must be avoided.—Koontz Bros., Electric Co., South Bend, Ind.

Electric Hoists—A circular describes the Moto monorail hoist of ¼- to 5-tons capacity, which is so designed that any stock motor of standard make may be installed; thus a plant may maintain a program of standardized motorization.—Drake Electric Hoist Co., Friendship, N. Y.

Repulsion-Induction Motors—A folder describes the R. & M. Type RA repulsion-induction motors rated from ½ to 7½ hp. inclusive. These are made to operate at 60, 50, 40 and 25 cycles on 110 or 220 volts.—The Robbins & Myers Co., Springfield, Ohio.

Waterproofing and Dampproofing—Specification Book A, the first of a set of six, gives new and revised specifications for waterproofing mass concrete, cement stucco, brick, masonry, and also describes various dampproofing paints, oil proofings and quick-set for cement. Eacn specification is complete with full information on how to use, quantity required and is illustrated with sketches.—The Truscon Laboratories, Detroit, Mich.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as
The Electrical Review

December, 1925

McGraw-Hill Co., Inc.
Chicago, Ill.

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NOW your electric power costs can come close to the bare kilowatt rate. Most maintenance items are killed by Timken Tapered Roller Bearings on motor shafts. Timken load area, high thrust capacity, positive roll alignment, and steel-to-steel rolling motion end the wear which drops the rotor dangerously.

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Volume 83 Number 12

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

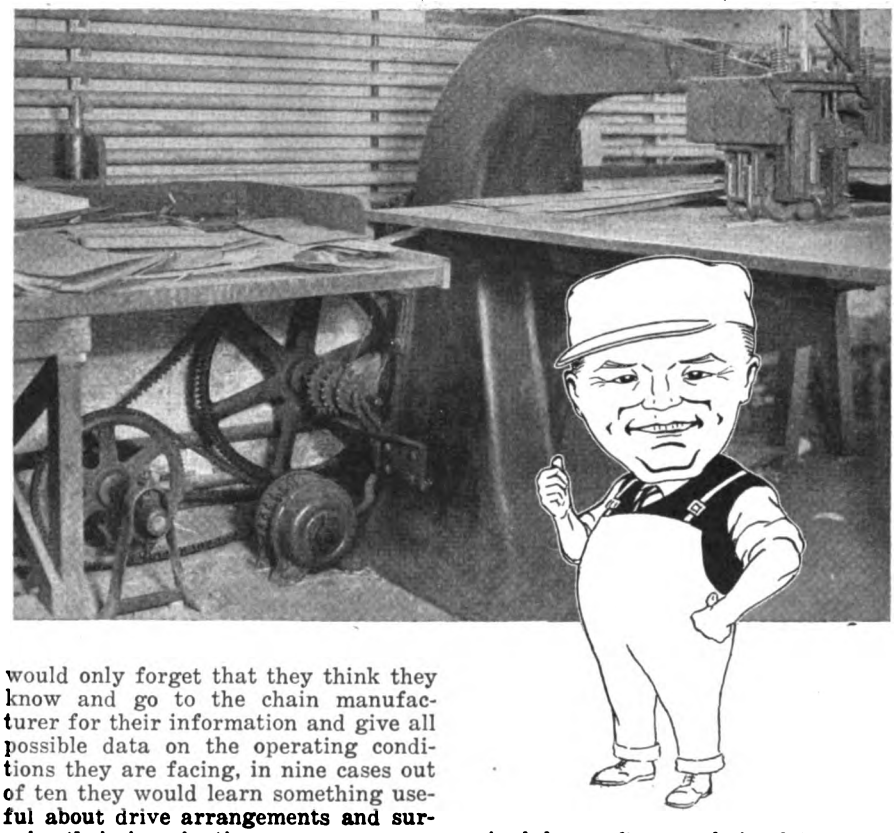
McGraw-Hill Company, Inc.
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Chicago, December, 1925

G. A. VAN BRUNT, *Managing Editor*

Are You a Bloodhound or a Setter

when working out new operating problems that appear to be what they are not?



HERE is a photograph of a motor drive that tells an interesting story. The problem first faced on this job was to furnish a machine speed so low as to seem unreasonable, without much expense and a complicated drive in a small space. How this slow speed of 40 r.p.m. was worked out with a standard 1,800 r.p.m. motor and two Morse silent chains is shown in this photograph. The chain connected to the motor reduces the motor speed of 1,800 r.p.m. to 267 r.p.m. and the second chain then reduces the jackshaft speed from 267 r.p.m to 40 r.p.m., giving just what was desired, with a speed reduction that has high efficiency and gives no trouble. There might be other ways of doing the job, but this one shows how a plant man used his head and saved himself a lot of trouble in hooking up this special machine.

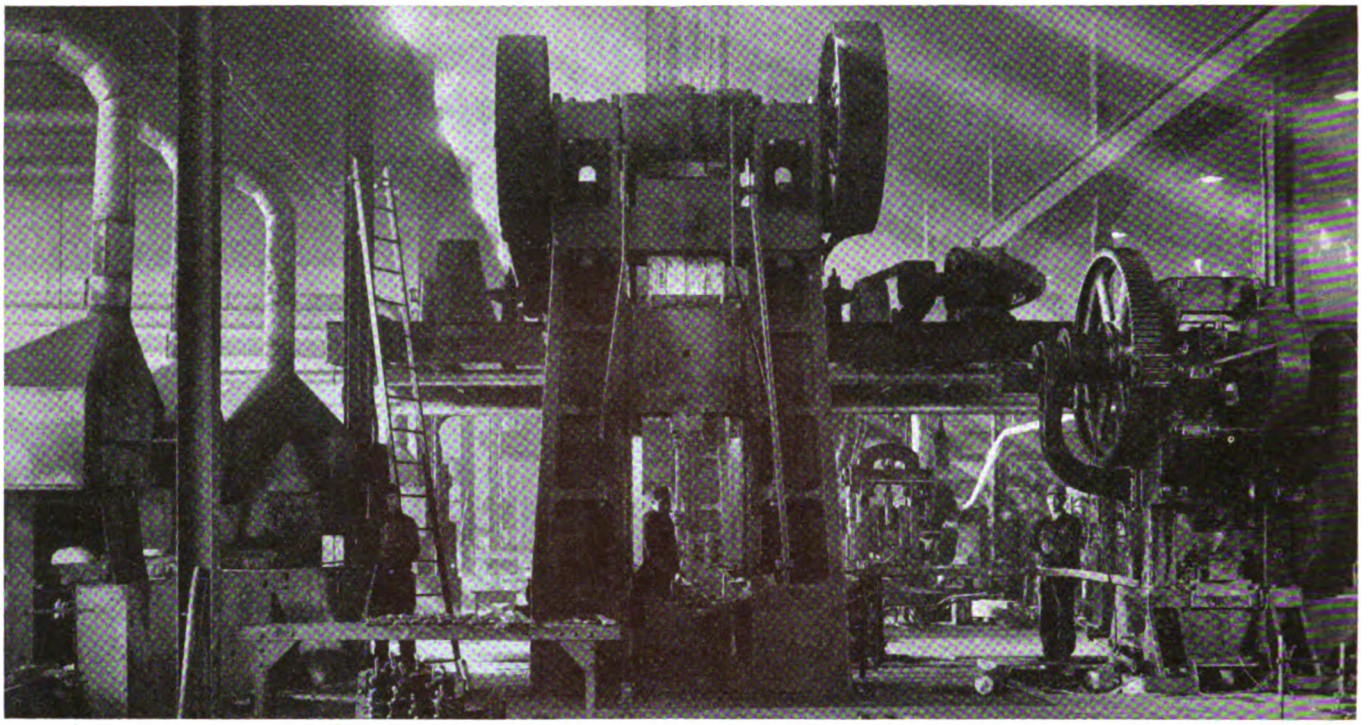
While on the subject of chain drives I want to give vent to some ideas of my own that you may or may not know, and may or may not agree with. We will not try to argue but just mention some facts. Every now and then you probably hear some wild statements about not being able to use a chain drive because of the noise it makes, or the limitations in the speed at which the chain must run. It is true that you can't run a chain at all the speeds of some direct connections of motor to machine, but in almost every case it is possible to use a chain drive without exceeding its speed limit of around 1,600 ft. per min. The trouble is that most men do not know how to figure the proper chain pitch and driving sprocket for a chain drive, and if they would only forget that they think they know and go to the chain manufacturer for their information and give all possible data on the operating conditions they are facing, in nine cases out of ten they would learn something useful about drive arrangements and surprise their imagination.

Now as to the matter of noise, if a chain drive is noisy it's not the fault of the chain, but is strictly up to the man who thinks he knows what a chain will do, but doesn't, and places an order on this information. Overspeeding the chain is actually the cause of noise in most chain drives. Moreover, by underspeeding the chain quieter operation can be secured than by using a low value of chain speed in feet per minute. Again, if there are possible surges in the load on a chain, a larger pitch is advisable. Still again, if the number of teeth in the driven sprocket is high, this spells at once a larger pitch than would ordinarily be used. These are just statements of fact without proof, and I realize that, but proof can be furnished by any chain manufacturer and that's the best place I know of to go for the proof. All I want to do here is to call your attention to these matters and suggest that you do no guessing with a chain drive but get first-hand information from a reliable source, and you will be surprised how often a chain drive or a combination of chain drives will save you a headache in hooking up a motor in a tight place.

Some one has said that a good engineer must have the good points of a blood hound and none of the bad ones of a setter. So take this for what it's worth and when you are thinking about using a chain drive, or are having trouble with one, hit the trail of the chain manufacturers. Like all other manufacturers who have been making things for a long time, they have a lot of good information tucked away that you can get for the asking; but if you don't ask—well you will be just like the setter that just "sets" until the man with the gun comes up and finishes the job.

Practical Pete

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An installation like this, which is in one of the shops of the Westinghouse Electric & Mfg. Co., presents several problems in lubrication. Here, in addition to heavy bearing pressures, shock loads and heavy, open gearing, the equipment must be operated under rather dusty conditions, all of which increase the difficulty of providing adequate lubrication.

Using Oils and Greases for Industrial Lubrication

with a discussion of what these materials are, how they are prepared, and considerations affecting their selection and application

By FRANK E. GOODING

Associate Editor, Industrial Engineer

A FAIR estimate of the amount of power lost or wasted in transmitting it mechanically would be approximately 10 per cent. Much of this loss is due to what is known as the friction load. A body started in motion will not continue to move indefinitely unless the force applied is continued. The stopping resistance is known as friction and is always present when two surfaces have a sliding, rubbing, or rolling contact.

The amount of this friction load depends largely upon the character of the material in the shaft and bearing, upon the quality of the surfaces in contact, the pressure between the surfaces in contact, the speed of motion, and also upon various substances commonly known as lubricants which may be introduced between these surfaces. There are, then, five elements which influence the friction load: the character of the materials in contact, the quality of the surfaces in contact, the pressure, the speed, and the lubricant.

Industrial plant men are particularly interested in the problems involved in overcoming friction in the bearings of industrial equipment, although similar problems exist wherever any two surfaces slide, rub, or roll on each other. Take, for example, an extreme case such as trying to rub two rough bricks across each other. The rough surface of one catches in the surface of the other and so may cause a very high friction or resistance to motion, as well as considerable wear on the surfaces of the bricks.

If a bar of soap is rubbed over the surface of each of the two bricks until a thick coating is applied, which fills the rough surfaces, they may then be slid on each other with considerably less effort or resistance and practically no wear or abrasive action, at least until the soap is worn away and the surfaces of the bricks come in contact. In this case the soap acts as a lubricant, and this illustration is a typical example of the action of a lubricant. What actually happens here is that the resistance to motion is decreased by the lubricant (in this case the soap) and the lubricant (the soap) is worn out instead of the surfaces of the material.

A good lubricant is a substance which can be placed between two sliding, rolling or rubbing surfaces, to decrease the friction between them, and which will keep them from wearing. This point cannot be over-emphasized as upon a clear understanding of it depends the selection and use of a lubricant. Further, the example cited above is not so far from being related to industrial lubrication problems, because many grease lubricants are merely mixtures of soap and oil. Also, graphite serves as a lubricant in almost identically the same way, as will be explained later in this article.

No matter how smoothly metallic surfaces are finished, or how perfect the surfaces may appear to be, there are always irregularities which hinder the motion of one on the other. Even though these irregularities are microscopic, they produce an abrasive action which in turn produces heat. This heat is

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the evidence of the friction that is present in the bearing or whatever the moving surfaces may be.

The purpose of lubrication is to interpose between the two surfaces a fluid film of such a nature that the metallic surfaces may be kept apart, so as to substitute fluid friction for metallic friction. That is, the film of lubricant fills in these irregularities and forms a coating over them in the same way that the soap covered and "lubricated" the surfaces of the bricks.

The Source of Oil Lubricants and Their Application

Mineral oil, which is the most common source of industrial lubricants, has been known to the world for centuries, but little use has been made of it either industrially or otherwise until in comparatively recent years. Today, petroleum and its products are more widely used than any other natural resource with the exception of steel. Many of the appliances made of steel would be utterly useless without the lubricating qualities found in the petroleum products.

The original use of petroleum, that is, in comparatively recent times, was as a burning oil, commonly known as kerosene and widely used as an illuminant. Of course, this demand led to the distillation of crude petroleum for the express purpose of obtaining burning oils, and such oils were limited in their specifications to exclude the lighter, more volatile and also the more explosive products.

The lighter products termed gasoline, naphtha and benzine were considered as byproducts, and their use was very limited. This was also true of the heavy oils that were left after the distillation of the kerosene. The heavier products were used for greasing purposes until the advent of high-speed machinery in the development of which mineral oils played an important part.

This situation has now changed materially, due to the development of the internal-combustion engine and the automobile. The lighter petroleum products have now assumed a place of superiority over kerosene; in fact, production and refining of crude petroleum for gasoline has difficulty in keeping abreast of the demand for motor gasoline.

The heavier oils, formerly considered byproducts, are also becoming useful as fuel in the operation of oil and Diesel engines while the still heavier oils form the group of products known as lubricating oils.

Lubricating oils form a range of petroleum products from light spindle oil to very heavy steam cylinder oils. The origin of these oils is varied and they differ with the region from which they come. For example, the Appalachian field produces a high-grade, paraffin-base crude, free from objectionable sulphur and from asphalt. These oils, which come from New York, Pennsylvania, Virginia, Kentucky and Tennessee, are rich in paraffin wax.

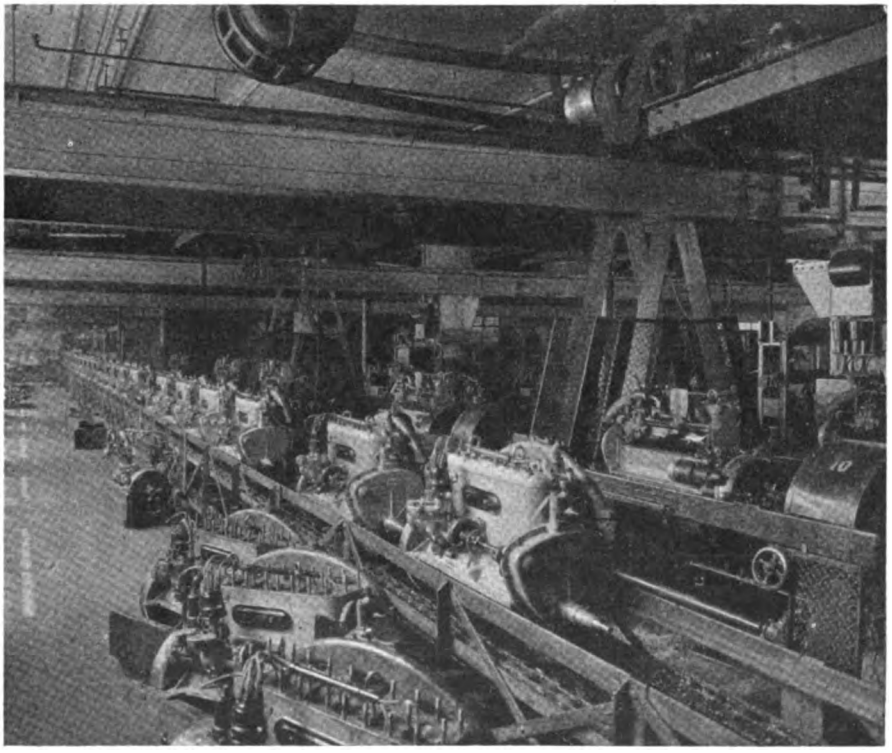
Approximating these oils in quality are the crudes found in western Ohio and northwestern Indiana, which states produce paraffin base crudes with traces of asphalt and sulphur. When these impurities are removed the oils are similar to the Eastern crudes.

The mid-continent field, comprising Kansas, Oklahoma, Texas and portions of Louisiana produces a variety of mixed crudes ranging in composition from a nearly pure paraffin base to a naphthene base, and containing varying amounts and kinds of impurities. The gulf coast field and the California field are producers of naphthene base crudes which are generally higher in their content of impurities than those from the other fields.

The three classes of crudes are handled somewhat similarly but the yields of products are quite different. Paraffin-base crudes are usually distilled with every effort to avoid decomposition by heat and yield the bulk of the high-grade lubricants. Naphthene-base crudes, on the other hand, will yield a greater amount of products when cracked, while mixed-base crudes are usually refined by a combination of the two processes, cracking and non-cracking.

Blending of lubricants is very common. They may be blended for viscosity, color, and other qualities. They may also be compounded with other oils such as rapeseed and lard oil to gain some special characteristic. In order to meet specific gravity specifications, oils may be mixed in certain proportions. Again, high cold and pour tests may be reduced by mixing with oils of lower test.

Compounding with oils other than mineral oils is often resorted to for obtaining special qualities. Cylinder oil, for instance, compounded with 5 to 7 per cent of tallow oil, adheres to the metal surfaces and produces a greater lubricating effect than would mineral oil alone. Animal



One of the problems of lubrication in plants working on cast iron is to have bearings tight enough so that the fine iron dust in the atmosphere cannot get into the bearings and score the shafts.

In particular, the large amount of conveying equipment which is found in many modern factories, especially in the automobile industry, presents an interesting problem in lubricating as it is exposed to the iron dust in the air and cannot easily be protected.

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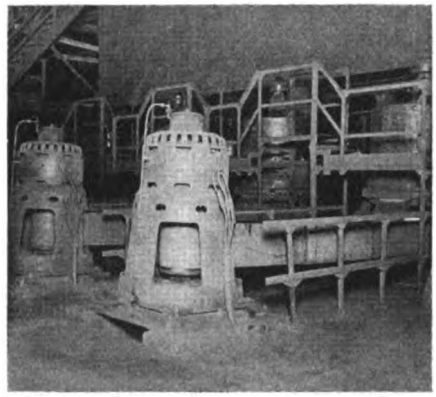
oils such as neatsfoot, lard, sperm and fish are used for compounding, as are also such vegetable oils as rape and castor.

One of the vegetable oils used as a lubricant is castor oil, which is made from the castor bean. This lubricant was much in demand during the World War for use on aeronautical engines. At present it is sometimes blended with other mineral oils to make lubricants for special purposes. Sometimes castor oil is used alone, although generally some mineral oil is added, when breaking in new bearings, because its stickiness is high. Extra-heavy mineral oils are also used for the same purpose. However, when pure castor oil is used for running-in a bearing and it is then desired to change to mineral oil, the bearings and the circulation system must be cleaned thoroughly because the castor oil forms a coating like varnish or shellac on the surfaces of the circulating lines. This coating is loosened by mineral oil and will clog the circulating system and interfere with the lubrication. For this reason, castor oil is seldom used alone, but generally has at least a small percentage of mineral oil in it to prevent the formation of this deposit.

According to the results of extensive tests by the government, castor oil is a heavy-bearing lubricant, and does good work for a while but may prove detrimental if used too long. It requires more frequent changing and renewing than do most other lubricants; also, it works better when hot, and therein is unlike mineral oil, which works best when cool. For this reason a different type of lubricating system is usually necessary for its use.

As stated before, castor oil has found favor with some operators for use when running-in-bearings on new equipment. Others find heavy mineral oil just as satisfactory. These opinions are usually based on the success or failure of experiments which may or may not have been carried on under the best operating conditions for the use of each kind of oil.

This difference of opinion calls attention to the necessity of having the proper conditions surrounding the use of any lubricant. Often, in the case of poor lubrication, the operating conditions, such as frequency of changing the oil, care in excluding dust or dirt, and the facilities for applying the oil to the bearings, are as much or more at fault than the lubricant used. Even the best lubricant for any certain condition may not give the best results unless it is applied properly.

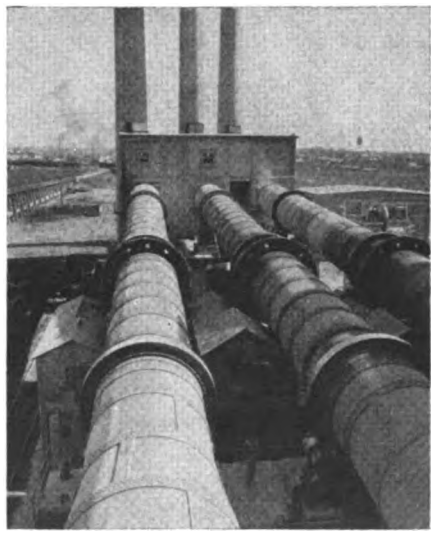


Conditions such as shown here present one of the most serious lubrication problems in industry.

This shows the large vertical motors which are used to operate centrifugal types of pulverizers in cement mills. The equipment operates at high speed and the bearing pressures are likewise very high. In addition to this, the atmosphere is always laden with dust.

Why Blending and Compounding Are Problems of Manufacture

Blending and compounding of oils are the problems of the manufacturer and only he can hope, with his wide experience in handling petroleum products, to effect a combination of these that will be satisfactory and have the qualities required of a lubricating oil for a specific purpose. Without this wide experience and the accuracy that goes with the large manufacturing plant, all blending and compounding become a matter of pure guess work.



Bearing pressures are very high and the dust problem is serious in connection with the lubrication of kiln drives in cement plants.

In such cases the lubricant must have sufficient body so that it will not be crushed out from between the bearing surfaces by the high pressure.

For example, it is sometimes necessary to have a compounded oil for use where a bearing or other part is subjected to water. It is very essential that the oil used have the property of emulsification so that it can take up some of the water in the form of an emulsion and, combining with it, produce a tenacious film and yet retain its lubricating qualities. Such an oil can only be produced by a knowledge of the actions of various animal and vegetable oils in combination with mineral oils and in combination with each other. In addition, there is required a knowledge of the proper proportioning of the various oils and the proper time and temperature of mixing so that a permanent combination will be formed.

Again, it may be a low cold test oil that is required. In this case, it is necessary to blend certain oils to produce that characteristic.

Greases constitute simply another method of applying oil and are useful in those places where it is difficult or impracticable to apply an oil. Greases are plastic compounds of lubricating oils and soaps made from animal or vegetable fats. Most semi-solid greases are mixtures of mineral oils and saponified animal or vegetable fats, such as tallow, lard, or palm oil. They may also be of a pure mineral nature, such as petrolatum. Petrolatum, however, is not strictly a grease in the sense that it is produced by emulsion or saponification. Some of the viscous gear lubricants, however, come in this class, as they are pure petroleum products.

How Lubricating Greases Are Made and Used

Some greases are composed of pure animal or vegetable fats such as tallow, lard and other non-fluid products. These have certain uses of a more or less special nature and do not constitute the general run of greases for lubricating purposes. Mixtures of pure, fixed oil fats and pure mineral greases, such as petrolatum, comprise another easily-definable group of products.

The common greases that are met with in everyday problems, such as cup, sponge and railroad greases, are mixtures of soaps and mineral oil. These are commonly known as "hot and cold set" greases, the cup and sponge greases being produced by the "hot set" process, while the

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railroad greases and axle greases are cold mixed.

Cup greases are usually made from what is termed a "lime soap base," having a content of 10 to 20 per cent fatty oil and sufficient mineral oil to bring the grease to the consistency required for the work. These greases are designated by numbers ranging from 0 or 00 to 6, with each number denoting an increasing degree of "hardness". The softer the grease, the greater the mineral oil content, as a general rule.

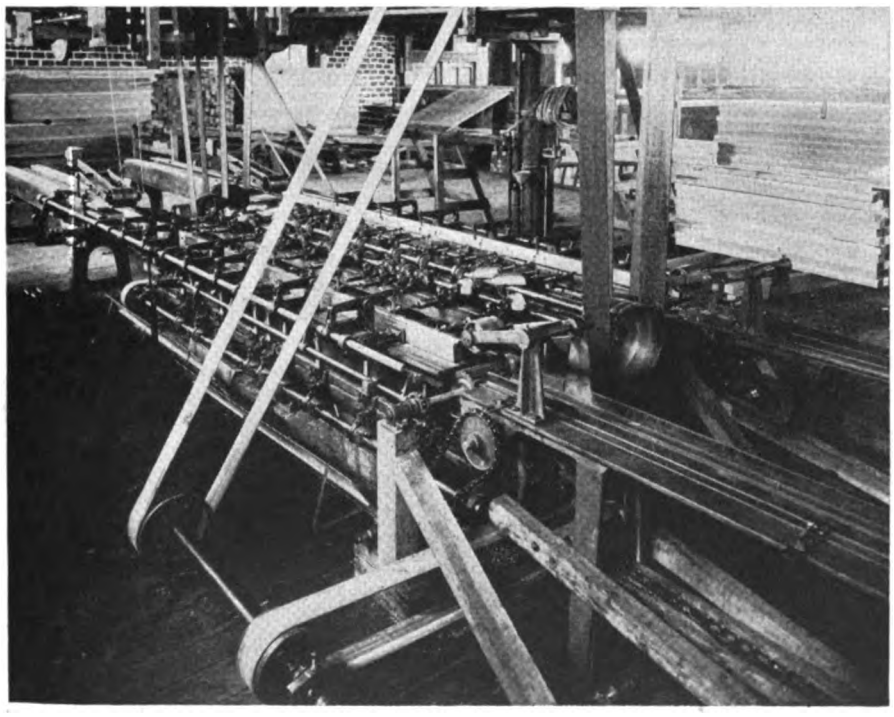
"Soda soap" greases are more difficult to make than cup greases and are called sponge greases. They may easily be recognized from the texture, which is fibrous and stringy, due to the process of manufacture.

Axle greases and similar hard greases are usually cold set greases and are made by mixing mineral oil, rosin oil and lime. Some greases contain fillers such as asbestos, talc, and soapstone, which really have no lubricating value. Only in rare instances where special characteristics are required is the use of these fillers justified.

It is obvious that, since a grease is made by adding a soap or similar material to a mineral oil, the quality of the product depends largely upon the quality of the materials used. For example, the fats added should be pure and sweet, instead of rancid and gummy. Where rancid fats are used, in the manufacture of a grease some scented material is usually added to cover up the rancid odor. Other factors in the manufacture of a grease over which the user seldom has any control are the necessity of proper cooking, mixing and proportioning of the different substances and the use of materials free from acids or impurities. These factors can be checked up by careful tests, but the average user does not wish to go to all of this trouble. For this reason it is advisable for him to make a careful investigation of each grade of product when first purchasing a lubricant and then trust to the reliability of the manufacturer, with perhaps occasional tests to see that the proper standard is maintained. However, more information on the testing of lubricants will be given in a later article.

One of the main reasons for using a grease in many cases instead of an oil is that the oil would run off the surface while the grease will stick until it is worked into the minute openings in the surface of the bearing. This is particularly true of heavy bearings and also of gear teeth. Until within the past few years grease has been generally considered as the only lubricant usable on heavy gears and bearings. Many of these bearing surfaces are not suited to retain any other lubricant.

Present lubrication practices, however, are tending very largely toward totally enclosing many of these bearings, and also gears, with the use of an oil circulating and cooling system whereby clean, cooled oil is circulated around through the bearings or the teeth of the gears. Frequently enclosed gears dip into a bath of oil. These improvements in lubrication practices have resulted in the very economical use of lubricants. Also they have increased the life of gears and bearings because these are always positively lubricated, while dust and foreign material are excluded from the lubricant, which is a big step in eliminating wear. Some of the methods of applying the various lubricants under different service conditions will also be discussed in a later article.



Complicated machines in industrial plant oftentimes present difficult problems in lubrication.

The large number of bearings and gears on this woodworking machine must be lubricated even though the woodworking industry creates considerable dust which settles in the lubricant and plays havoc with open bearings. Also, such equipment usually operates at a comparatively high speed. In addition, in this installation there are several chains as well as bearings to be lubricated.

Uses of Graphite in Connection with Lubrication

There is still another substance, graphite, which is quite frequently used in connection with other material for lubricating the bearings of industrial equipment. Graphite is a form of pure carbon; charcoal and diamonds are other forms of pure carbon. The so-called lead in lead pencils is usually graphite. It also has some electrical uses. Graphite is mined and in its natural state contains a number of impurities. There are two forms of graphite, flake and amorphous. The flake graphite is the form most commonly used for lubrication and is so called because it is found naturally in the form of flakes, somewhat on the order of mica. Because graphite as found in its natural state contains impurities much care must be exercised in its manufacture to remove them. The graphite is first ground fine, which still leaves it in minute flakes. One method of preparation involves flotation of the finely ground graphite in air or liquid where the impurities are separated out because of the difference in the specific gravity of the impurities and of the graphite. By special methods, graphite of almost 100 per cent purity can be obtained.

A simple method of testing graphite for impurities in it which would affect the bearing is to take some of the graphite and place it on a piece of glass. If the graphite is rubbed down and smoothed out with a thin-bladed knife, the scratching

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of any solid impurities can be heard. They will actually scratch the glass also. From this it can be seen that unless a graphite free from solid impurities is used in a lubricant the effect on a bearing will be much the same as putting emery dust in it.

Although the flake graphite is a lubricant in itself, it is not generally used alone but usually in connection with an oil or a grease. Many manufacturers can furnish various grades of oil or greases with the graphite already mixed in them. It is usually more difficult to mix a graphite with a grease than with an oil because of the difficulty of getting a proper mixture. This is largely because it is generally not advisable for a user to melt a grease lubricant so that the graphite can be more thoroughly mixed, because he is not familiar with the critical temperature and the care necessary in handling a grease at the melting temperature. Some greases would be spoiled by bringing them up to the melting temperature or at least would not be the same quality of grease when again solidified.

How Graphite Lubricants Act on Scored Bearings

As stated before, even the most highly polished bearings in industrial equipment are not entirely smooth, as is shown by the microscope. The function of the graphite lubricant is to fill up the fine and even coarse openings or rough spots and so make a much smoother bearing surface so that it is more easily lubricated. For this reason graphite is very commonly used on scored bearings and also when running in a new bearing. It is not generally advisable to use graphite when oil grooves are cut in the bearings as the graphite will soon fill them up. If graphite is used during the running-in period the grooves should be thoroughly cleaned out before the bearing is put on a strictly oil or grease lubrication basis. Graphite is sometimes put in with the lubricant where a bearing starts to run warm and it is absolutely necessary to maintain the machine in service. This is common practice among engineers where a shutdown would mean stopping the entire plant. Practically any old-time engineer can "coax" a hot bearing with graphite until closing down time. In this case, also, the bearings should be cleaned out at the first opportunity.

Where there is a high bearing pressure, graphite serves still another purpose. In some cases the lubricating oil or grease would be forced out from between the bearing and the shaft by the high pressure, as, for example, in heavy roll bearings, large gears, particularly with cast teeth, and in other similar duties.

Under these conditions, the addition of graphite to the lubricant gives the lubricant a body which separates the shaft and bearing so that the oil or grease is not forced out entirely. Many of the heavy gear greases contain graphite which is used to fill up any inequality in the surfaces and also to form a coating on the teeth or bearings and shaft which takes the pressure and lubricates the surfaces in exactly the same way as would soap used on the surfaces of the two bricks mentioned previously. The graphite forms a slippery surface, fills in the inequalities in the surface and wears out instead of the metal wearing. An oil or a grease serves exactly the same purpose, although this function may not be as easily understood because oils and greases do not have the body that graphite does.

Because graphite will stand high temperatures it is very commonly used in connection with the lubrication of conveyors in ovens, kilns and other places where the heat quickly destroys all other lubricants. In such cases it is generally mixed with some form of grease so that it can be more easily applied to the gears or surface in contact. Because graphite is an electrical conductor it is not generally advisable to use it, except sparingly in emergencies, around electrical equipment.

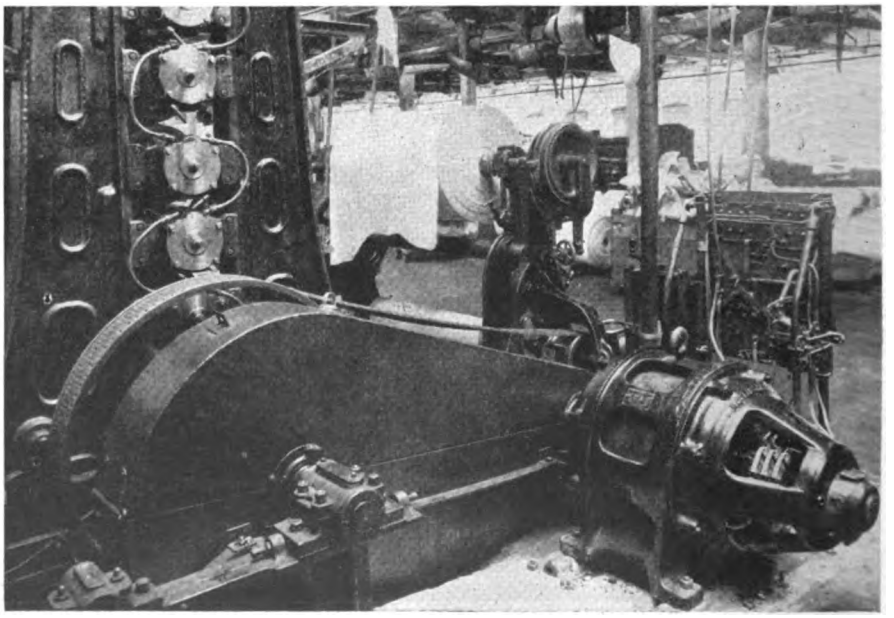
Some Suggestions on the Use of Oils and Greases

Fluid friction is naturally less than metallic sliding friction and is productive of little heat. The heat produced by friction within the lubricant, called fluid friction, is a measure of the suitability of the oil for the job. A bearing, for instance, may run excessively warm because of a too-heavy oil which causes an "oil drag". The oil drag may be so pronounced that it may be mistaken for bearing trouble of a mechanical nature, but in reality it is nothing more than the friction within the oil itself.

Oil that is of the correct body to meet the conditions of service will develop little friction and a well-designed bearing lubricated with the correct oil should develop little rise above room temperature.

Bearings are commonly lined with a composition metal such as babbitt, or they may be bronze-bushed. These linings and bushings are used with the idea of reducing the friction in the bearing. It is well known that "anti-friction" metals have a tendency to reduce the frictional resistance to motion. Steel on cast iron, or on bronze, or on babbitt metal will produce less friction than

Paper mills offer a difficult problem due to the high bearing pressures and the hot, wet atmosphere. In such cases it is not at all uncommon to use forced-circulation lubricating systems in which the oil is circulated through the bearings, cooled, filtered and returned for reuse. In addition, in this installation, the chain drive is totally enclosed and operates in a bath of oil which not only protects but lubricates the chains.



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steel on steel. However, under conditions of good lubrication when a complete film of oil is present, the nature of the metals makes little difference as far as the frictional resistance is concerned. The oil, by maintaining a film between the shaft and the bearing surface, keeps the rubbing surfaces apart and floating on an oil film.

Grease used as a lubricant has not the free flowing qualities that an oil has. The soap or sponge acts as a carrier for the oil, but remains also to partially nullify the effect of the oil. It is, therefore, obvious that many grease-lubricated bearings will run slightly warmer than if lubricated with an oil, due to the greater internal friction of the lubricant. In some bearings the clearances are so small that it is impossible to use anything but a very fluid oil. Such bearings are usually of the high-speed type and, therefore, the losses in frictional resistance must be kept as near to a minimum as possible.

Effect of Speed on the Choice of a Lubricant

In large, slow-speed bearings, the clearances are large and the opportunity of using a heavy oil or a grease is excellent. The frictional losses in the lubricant, due to the slow speed will be small in comparison to the power delivered. On slow-speed shafts, frictional losses are a minor consideration, the maintenance of the complete lubricating film to withstand the heavy pressures usually encountered in slow-speed shafts being the essential requirement.

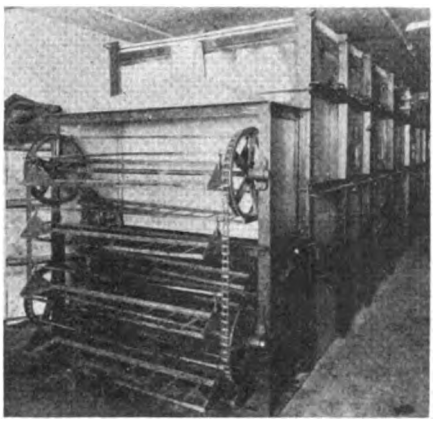
The speed of the rotating shaft has a very important effect on the lubricant to be used. For example, in the small, high-speed shaft, a light oil is primarily necessary for the small clearances. It is also necessary because, due to the high speed, only a quick-acting oil will form and maintain a constant film and a complete film that a heavy oil cannot form and maintain at the high speed of the shaft.

The heavy, slow-speed journal must have a heavier oil that will not run out at the bearing ends nor be squeezed out under the pressure of the shaft. It must also maintain the film under the conditions of slow speed, which are not so conducive to the maintenance of an oil film as are high-speed conditions.

Friction of lubricated surfaces, therefore, is not so much a theoretical problem of surfaces and speeds as it is a consideration of the practical features of the best obtainable lubricants, as well as the conditions under which they are to operate. That is, the oil or grease should be of the proper viscosity to serve the purpose at the operating temperature to which it will be subjected.

Assuming that the method of applying the lubricant is modern and reliable in its operation, friction of working surfaces becomes only a matter of fluid friction, which is best taken care of by the application of common-sense principles in the selection of lubricants. Oils can be so selected that they will eliminate metallic friction completely and with it, wear, abrasion and heating, substituting for it an easily supplied fluid, thereby reducing friction to a minimum and reducing power losses due to friction and much of the bearing trouble to a negligible quantity.

A discussion of the viscosity and other characteristics of lubricants, together with practical methods of testing them will be taken up in another article to appear in an early issue.



Conveyors in ovens, kilns and other equipment operating at high temperatures offer a particularly difficult problem in that the lubricant is melted off under ordinary operating conditions.

For operating in high temperatures, graphite is frequently used, sometimes in connection with a grease. The grease is used to distribute the graphite and burns out from the heat.

EDITORS' NOTE: Special acknowledgment is made to the Vacuum Oil Co., New York City, for valuable information and assistance in the preparation of this article. Other companies who have co-operated are: Dearborn Chemical Co., Chicago, Ill.; Jos. Dixon Crucible Co., Jersey City, N. J.; The Pennzoil Co., Oil City, Pa.; Standard Oil Co. of Ind., Chicago, Ill.; Superior Flake Graphite Co., Chicago, Ill.; The Texas Co., New York City; Waverly Oil Works Co., Pittsburgh, Pa.

One Way to Install Tanks to Prevent Bottom Rusting Out

PROPER installation of steel tanks, of which practically every industrial plant has several, has much to do with their life. I found a good example of this several years ago and, as a result, now install all tanks in a way which prevents their bottoms rusting out.

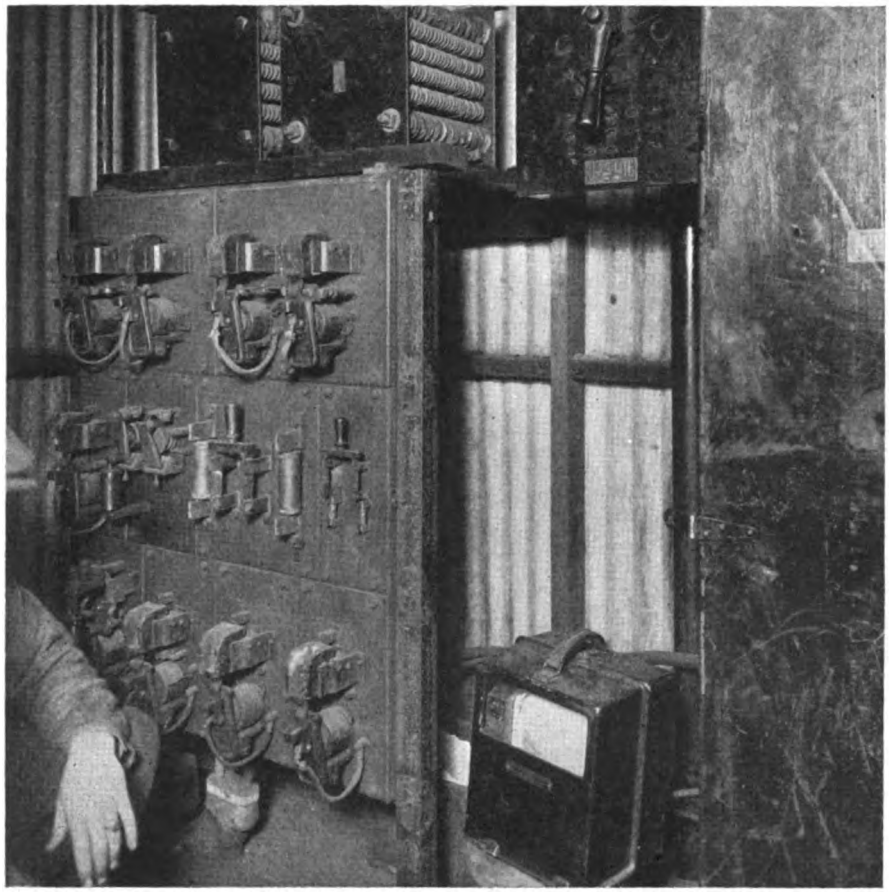
While dismantling an industrial plant, I removed a number of circular steel bins that had rested on a concrete platform. The concrete projected beyond the sides of the tanks, and so permitted rain to run in between the tank bottom and the concrete. The bottom plates were so badly rusted that the tanks had no salvage value, and could have been used only a short time longer. As a result, whenever possible, I keep the concrete back from the sides of any bins and tanks that I install; that is, I allow the tank to overhang the concrete by an inch or two. When painting, thick paint is applied to the bottom edge of the tank in such manner as to form a "drip" which prevents the rain creeping under the tank bottom. A number of tanks thus installed have given very satisfactory service.

Bins and tanks are set on foundations that vary from earth to elaborate structures. Earth foundations are liable to wash out and the consequent local settlement may break pipe connections. Covering the area with crushed stone, well rammed, makes a better foundation. A foundation that combines effectiveness with good appearance, and one that has given the best of satisfaction, is made of a thin circular wall or ring of concrete, if the tank is circular, which allows the tank to overhang as described previously. The inside of this wall is filled with earth covered with fine stone or sand, which supports the load in the center.

The wall need not be reinforced unless it is desired to avoid shrinkage cracks. If the foundation is large, the circular form for casting the concrete may be made from thin lumber. Narrow boards, not necessarily tongue-and-groove flooring may be nailed to girts sawed in circular form, which gives the concrete the desired shape. A foundation need not be constructed exactly round; the boards give it the shape of a many-sided polygon, which is satisfactory. C. O. SANDSTROM.

Los Angeles, Calif.

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With this graphic meter set up, tests are made of the overload relays, the accelerating relays, and a chart taken of the load cycle. This data recorded on the graphic meter chart makes a worth while performance record of the motor and control.

How a coke plant is

Using a Graphic Meter for Setting Overload Relays

and accelerating relays on controllers for motors, together with typical graphic charts and an explanation of how to interpret the results obtained

By G. A. SHARLAND
Electrical Engineer, Minnesota By-Products Coke Co., St. Paul, Minn.

THE importance of continuous operation and low operating costs of electrical installations in industrial plants is a matter that is every year receiving greater attention by operating executives. High-grade equipment is purchased that will invariably fulfill the conditions for which it is specified, provided that it is correctly adjusted and receives skilled attention.

The protection of electrical machinery has been gradually developed from the exposed link fuses that were dangerous and unreliable to the accurate and perfectly safe circuit breakers and overload relays of the present day. However, for the overload relays and the circuit breakers to perform their function they must be adjusted to trip at currents that are hazardous to the equipment protected. While the current at which an instantaneous trip circuit breaker or overload relay will open, cannot be accurately determined by means of an indicating or graphic ammeter, an ammeter, and especially a graphic instrument, will enable one to set a breaker sufficiently closely to insure that the motor and driven machinery will be adequately protected. The advantage obtained through the use of the graphic meter lies in the fact that a visual record is obtained of the load conditions during the test and if the current is slowly brought to a maximum, an accurate record of the tripping point is obtained.

In testing to insure that the protective equipment is properly adjusted, there are four factors to be considered. These are:

(1) The setting of a circuit breaker or overload relay to protect against short-circuits or instantaneous overload.

(2) The adjustment of the time-limit devices on overload relays and circuit breakers so that momentary overloads can be taken care of.

(3) The setting of current-limit accelerating relays on magnetic controllers to give proper protection during acceleration, so that the time of acceleration will be the minimum consistent with low starting current.

(4) The protection of induction motors against overload and single-phase operation.

Let us first consider the adjustment of the instantaneous trip and time-limit trip on overload relays and circuit breakers as mentioned in Cases 1 and 2 in the foregoing. A case in point is the Electric Controller & Mfg. Co. crane protective switchboard giving overload protection to the motor on a coal-charging car. The motor on this car is a General Electric type MD-104½, direct-current, series-wound motor rated at 35 hp., 220 volts, and a full-load current of 173 amp.

On this crane switchboard are two overload relays, one having a range of 150 to 300 amp., and provided with an inverse time-limit trip and the other having an instantaneous trip with a current range of 200 to 400 amp. The function of the inverse time-limit overload relay is to protect the motor against sustained overloads of more than 25 per cent in excess of its rated load, while the purpose of the instantaneous overload relay is to protect the motor and driven equipment against sudden and severe overloads such as might be occasioned by putting the motor on full line voltage with all the starting resistance cut out.

It was decided that for proper protection of the motor, the instantaneous overload relay should be set to trip at twice the full-load motor

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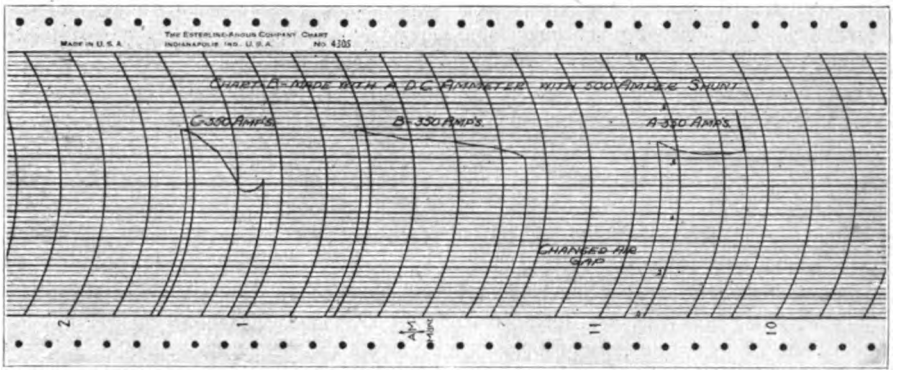


Fig. 1—Graphic ammeter chart taken during testing of trips on instantaneous overload relays.

current or 350 amp., and that the time-limit overload relay should be set to trip at 30 per cent overload, or 235 amp., in 25 seconds.

In resetting each relay, the operating coil of the relay was connected in series with a 500-amp. ammeter shunt and a water rheostat, all of which were connected across the 220-volt, direct-current power supply. By moving the plates of the water rheostat closer together or farther apart, the resistance could be changed and the current varied to meet the required value. An Esterline-Angus graphic ammeter was connected to the shunt so as to obtain a graphic record of what was taking place.

The setting of the instantaneous relay was determined by gradually raising the current, the plates of the rheostat being slowly brought together. Time was not taken into consideration in determining the tripping point on this relay. The air gap in the magnetic circuit was then adjusted until the correct tripping value was obtained. Four tests, shown on the chart in Fig. 1, were made. The results were:

Curve	Tripping Current	Remarks
A	330	As received from manufacturer.
B	330	Changed adjustment of air gap.
C	350	
D	350	

In making the tests shown in Fig. 1, a value of current is applied to the relay which is below the tripping point; the current is then gradually increased as is shown by the curve, particularly in the case of curve *C* in Fig. 1, until the trip point is reached, when the graphic meter pointer goes to zero.

In setting the time-limit overload relay a number of preliminary tests were made to get as close as possible to the specified tripping current. Adjustment of the air gap of the relay was made to obtain the proper value of tripping current. After this was done the time taken to trip for a given current was taken by means of a stop watch. The water rheostat was then set to give the specified tripping value of current and this current was applied to the relay, time being taken on the stop watch to ascertain the length of time required to trip at this value of current. While it was recognized that the time could be obtained directly from the graphic meter chart, when set to travel at 12 in. per min., a stop watch was used as a check on the results. The time limit was adjusted by varying the size of the oil holes in the dash pot of the relay. Tests were made as shown in Fig. 2. The results obtained in these tests are as follows:

Curve	Tripping Current	Time	Remarks
A	228	28 Sec.	Setting as received from factory. Time limit changed.
B	282	14 Sec.	Time limit changed again.
C	270	12 Sec.	
D	240	27 Sec.	
E	240	25 Sec.	

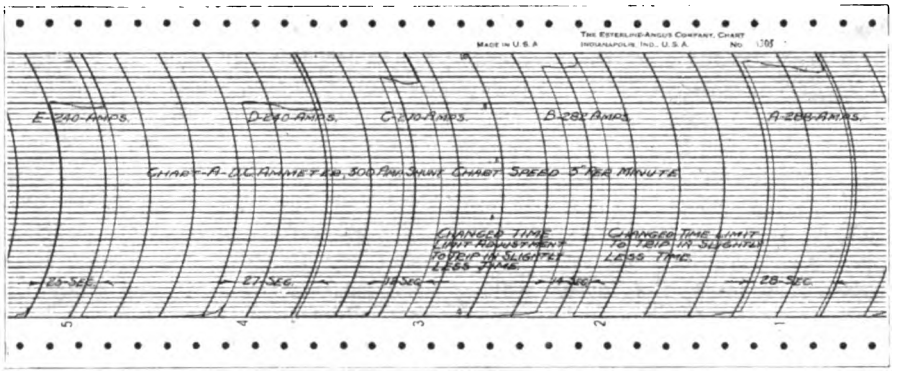


Fig. 2—This chart shows the tripping current and time required to trip on a test of a time-limit overload relay.

The setting of the time-limit overload relay was left as shown in curve *E* of Fig. 2, as it was thought that this was sufficiently close to give the motor suitable protection.

In the starting and acceleration of motors it is desirable that the change from partial to full voltage, that is, the cutting out of the starting resistance, should be at a rate that is consistent with the capacity of the motor. In other words, as mentioned in Case 3 in the foregoing, the accelerating relays on magnetic controllers should be set to bring the motor up to speed in the shortest possible time consistent with proper protection of the motor.

A typical example of this is a direct-current series motor driving

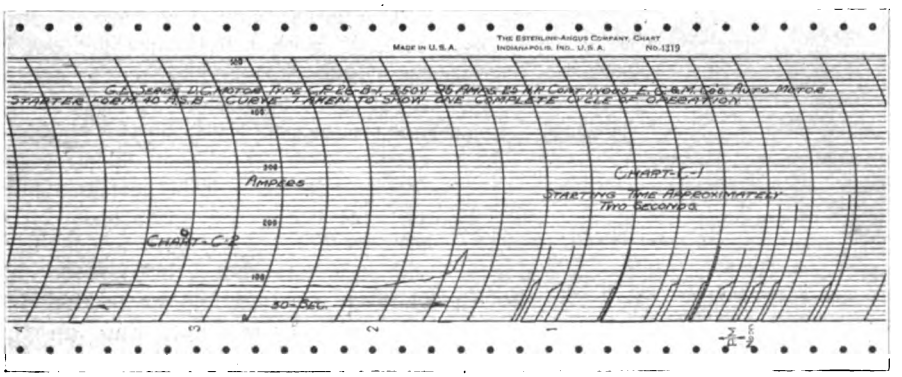


Fig. 3—Adjusting accelerating relays by the use of a graphic ammeter.

The first curves at the right show that a peak current of 250 amp. was reduced to 140 amp. as shown. by changing the adjustments of the acceleration relays.

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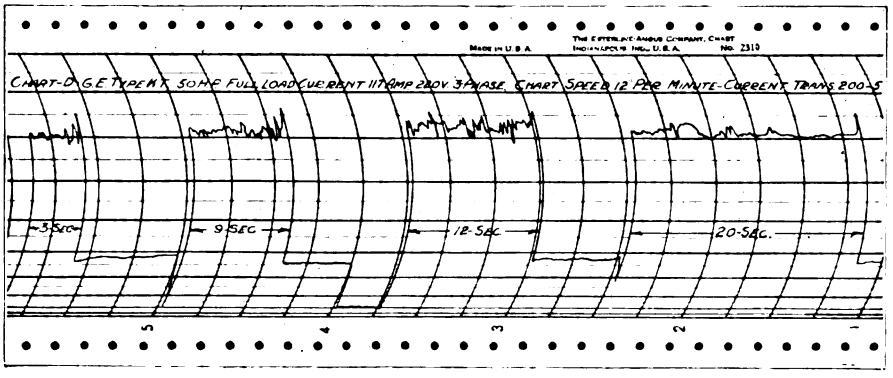
an air compressor. This motor is controlled by an automatic magnetic controller that is caused to function by an automatic pressure regulator, which is set to start the motor at 40 lbs. per sq. in. of air pressure and stop it at 85 lb. per sq. in. pressure. As the equipment started and stopped about 300 times a day, it was desirable that the starting current be kept to the minimum value consistent with the motor being put on the line in the shortest possible time.

The motor used is a General Electric 25-hp., 250-volt, direct-current, series-wound motor. It is controlled by means of an Electric Controller & Mfg. Company form ASB magnetic starter. This starter has four accelerating relays which cut out successive steps of the accelerating resistance. A 500-amp. ammeter shunt and graphic ammeter were connected in series with the motor armature and the chart shown in Fig. 3 was taken. Full-load current on the motor is 95 amp., and from the chart it may be seen that the first test showed that the accelerating current was reaching values of 240 amp., or approximately 250 per cent of full-load current. By changing the current adjustment on the accelerating relay this was reduced to 140 amp., or approximately 150 per cent of full-load current. Under these conditions, the motor started in 2 sec. which is plenty fast enough for the conditions of operation that we have to contend with. Chart *C-1* in Fig. 3 shows the test made for determining the correct adjustment of the accelerating relays. Chart *C-2* in Fig. 3 is a high-speed chart and shows a complete cycle of operation which includes starting up, compressing air, and shutting down.

The setting of overload relays on polyphase induction motors is the same as on direct-current motors, both for the current and for the time-limit adjustment. However, one of the most frequent causes of the failure of polyphase induction motors is the opening of one wire to the motor. When this condition exists the motor will, if running, continue to operate single-phase and will take 173 per cent of the current that it would take under normal operation. With the overload relays adjusted to take care of overloads of 125 to 150 per cent of normal full-load current, the overload relays will prevent single-phase operation of the motors. However, it is essential that a check be made to insure that these overload relays are set sufficiently low to take care of this condition. A test was made on a 50-hp., 220-volt, three-phase motor which drives a centrifugal pump. This motor is controlled by a manually-operated compensator. Overload protection for the motor is provided by two General Electric Company Type P, Form C-46 overload relays. Full-load current of the motor is 117 amp. It was felt that 150 per cent of full-load current would be the proper tripping point for the overload relays. Inasmuch as 135 per cent of 117 amp. is approximately 160 amp., the overload relays were adjusted by the calibration plate to 160 amp., and then by connecting a graphic ammeter in the circuit by means of a 200-to-5 ratio current transformer the chart shown in Fig. 4 was taken. As can be seen from the chart the overload relays function properly at 160 amp. It was found that the time required to trip was 20 sec. This was thought to be too long, and was reduced to approximately 5 sec.

In conclusion it may be said that the successful operation of motors depends largely on the overload protection that they have and how accurately the overload relays are set. With the proper setting of relays it is possible to obtain a condition wherein one reduces to a minimum the number of shutdowns consistent with the maximum protection to equipment. Adjustment of relays is easily made by means of a graphic meter having a high chart speed; this procedure has the further advantage of giving a permanent record of the setting, both as to the current necessary to trip and the time required to act.

Fig. 4 — Testing the overload relays used with an induction motor to determine whether they will protect the motor against overloads and single-phase operation.



Arc Welding Cuts Repair Cost in Cement Mill

AS BEING a typical instance of the large savings that can be made in plant repair work by the use of electric arc welding in place of riveting, for joining pieces of metal, the Lincoln Electric Company's research department at Cleveland, Ohio, has compiled figures covering certain features of such work in cement mills. Based on actual and numerous instances of repair work on dust chutes in cement mills, it was found that a patch welded by the electric arc costs in tangible expense only about one-thirtieth of what the same job would cost when done by the riveting method. The following comparison of the cost of a repair job which requires putting on a 4-in. by 4-in. patch, in a cement mill, shows typical costs of doing the work.

RIVETED METHOD

Two men required for 2 hr.

Operation	Cost
Drill holes	$1.20
Fit up	.60
Rivet	.60
Total	$2.40

WELDED METHOD

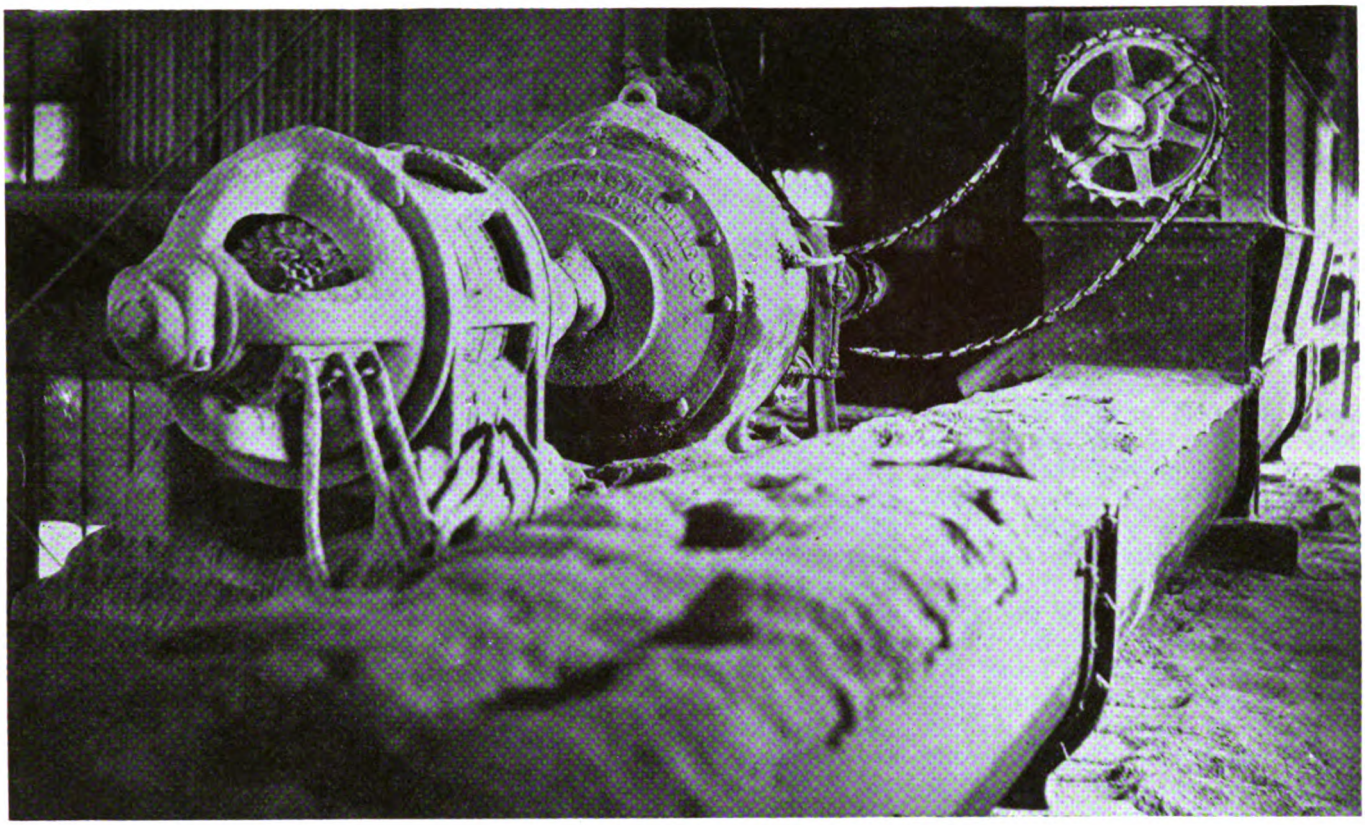
One man required for 5 min.

Operation	Cost
Weld patch	$0.08

On this particular job where the riveting method was used, the cost included labor, power, and rivets. In the case of the welded job, labor, power, and welding wire are included.

One advantage of the arc welding method is that little preparation is required. When riveting, the equipment must be shut down in order to let a man get inside of the chute to do the riveting. Where electric arc welding is used, it is not necessary to shut down the operation of the chute. The job is done from the outside, no holes have to be made and there is no occasion, as in the case of riveting, for matching up the holes in the patch and the chute.

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Dust is one of the big factors which affect the operation of plant equipment, as may be seen here. This direct motor drive through a Foote Bros. Gear & Machine Co., Chicago, Ill., speed reducer operates a trough screw conveyor in a cement mill.

Some of the

Maintenance Problems in the Small Plant

that have an important bearing on production, with suggestions on how they may be solved satisfactorily in the absence of a highly trained organization

By MAURICE C. COCKSHOTT
Engineering Department, Emsco Steel Products, Los Angeles, Calif.

ONE OF the difficulties incidental to the work of the maintenance organization in the small, and especially the isolated, mill or plant employing approximately 100 to 150 men, is that often the work must be done by less highly trained or specialized men than are found in the larger plants. The small plant obviously has less of this work to do and so can generally get along with less highly trained supervision and less skilled men to do the work. In consequence the work is more likely to be conducted in somewhat haphazard fashion. Further, proper facilities may be lacking for handling maintenance and repair work in an efficient manner.

These and other problems are discussed in this article, and suggestions given on ways of making the best of the circumstances which result from the conditions that are present in the small or isolated plant and cannot be wholly eliminated.

The department which requires the most attention from the maintenance workers is generally the power plant, where cleaning boilers, relining and repairing furnaces, and other similar duties occur periodically. This, however, is such a special subject and the problems so similar in all types of plants that it will not be discussed further here. It is well to keep in mind, however, that in the small plant this work is generally done by the general repair gang, while in larger plants the power department may have its own gang of men.

In mill and factory maintenance there are three types of equipment —motors, belts and bearings—common to practically all industries, which require a large proportion of the attention of the maintenance workers and the operating men. Continuous operation is largely dependent upon the reliability of all of these elements of the power drives. Attention given to any of these is usually amply repaid in more satisfactory operation with few interruptions.

In the plant proper the equipment which should receive the most careful attention is the motors. It is not true that the motors require the most maintenance and attention, but it is generally true that the amount of care and attention given to them affects the amount of actual maintenance and repair work which may be necessary. Inspection and care seldom interfere with production; breakdowns stop production until a repair or substitution can be made. For this reason, it is well to consider the following facts about industrial motors.

Except where heavy starting torque is required, as on fans, kilns and compressors, the squirrel-cage

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motor is in general use in all industrial plants. In mills where service conditions are unusually hard, the rugged construction nables this type of motor to give very reliable service. Where motors are housed in as a protection against dust and wet they will not need much maintenance beyond blowing out with an air hose at regular intervals. With motors of the slip-ring type, the brushes require attention, especially if in a dusty location.

It is good practice to put the motor overhead, or on a well-raised base rather than near the floor, as this helps to prevent the entrance of chips and foreign matter. Whenever it is necessary to place the motor in a hot corner some air circulation may be obtained from a fan keyed on to the shaft, or the motor can be purchased with fan blades built in as a part of the rotor. All starters, controllers and relays, must be kept in as clean a part of the mill as possible, inspected regularly, and cleaned and lubricated. This latter should not be done by the regular oiler, but made part of the electrician's duties. It is well to take a little care in choosing the place of mounting such equipment as generally one side of a machine is cleaner than the others, due to the way the material is fed, or to the location of a window, or to other surroundings.

How to Get the Best Service From Belt Drives

Belt drives are another important and often much-neglected part of the power service equipment in the small plant. Frequently the policy of purchasing the cheapest belt obtainable is followed where belt life is short, due to the severe operating conditions. In such cases the cheapest belt will often last as long as another belt which may be higher in price, but no better suited to the conditions. Under conditions which are ideal, and in many cases where they are not, it is hard to beat the leather belt. Any type of belt should, of course, be installed to suit the particular type of drive which it serves and be maintained properly. On drives which have paper pulleys, the crown should be checked up from time to time. In an emergency, this crown can be built up temporarily by means of adhesive tape although there are other products on the market which are better and more lasting. All belt drives must be kept up to the tension that will give the maximum efficiency. Especial care needs to be given to new leather belts until they have become run in. It is not good policy to draw them too tight when installed, but rather to take up any stretch gradually.

Plants which have belts operating under severe conditions can usually find one or more special types of belts which are made by some method or of some material that is not affected by the service conditions. There are literally hundreds of these belts on the market which are designed to be used under some special conditions of heat, cold, wet, dry, abrasive dust, shock load, or any of the possible combinations of these which may be met in industry. It is well to study the claims of the manufacturers and the construction of these belts and then try out the belt which seems to be best, taking care in each case to follow the manufacturer's recommendations on method of installation, type of fastener to use, side to go next to pulley, crown, speed, and any other operating factors.

It should be remembered that because a belt solves one difficult operating problem, it does not necessarily mean that it will work as satisfactorily under other severe conditions. I have found that in hot and dusty surroundings a rubber belt, when properly applied, will give satisfactory service. Successful power transmission will depend, however, upon using a belt with the correct number of plies of material, and upon the use of pulleys of the proper diameter so that the belt operates at the right speed for the power to be transmitted. If these factors of speed, plies, and diameter of pulleys are not properly balanced, the frictional heat will break down the material and the life of the belt will be short. The manufacturer will give recommendations. Another advantage of rubber belting is that it is waterproof. This makes it usable also in hot and wet atmospheric conditions.

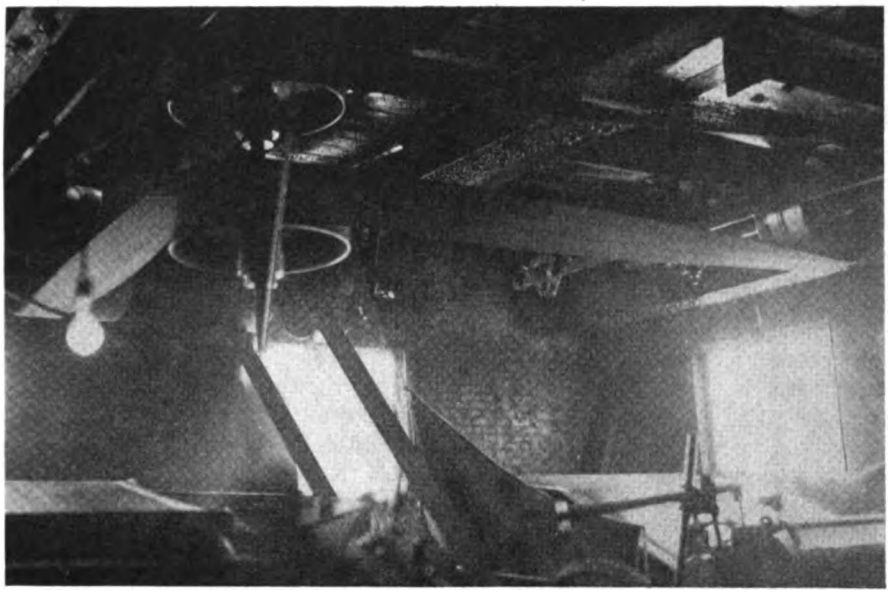
The belt fastener is of much more importance than is usually considered. There are many types of fasteners on the market and in most cases each of these types is made in various sizes for different weights of belts, diameters of pulleys, and so on. Often much of the trouble attributed to belts, and classed as belt failures, is due to the use of the wrong type or size of fastener, or to an incorrect application, such as, belt ends not square, joints not true, fasteners too near the end of belt, and so on. In choosing fasteners I have given preference to the hinged type of fastener with rawhide or Bakelite pins on belts up to 8 in. wide and of medium thickness. On larger sizes I use, generally, a fastener of the plate-and-rivet type



Proper lubrication is of prime importance in industries where dust is a factor.

On belt conveyor installations such as this, the pressure grease gun system of lubrication has many points in its favor. The pressure under which the grease is applied forces any foreign matter out of the bearings and fresh grease into them. This installation was made by the Stephens-Adamson Mfg. Co., Aurora, Ill.

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In this case, a different type of belt overcame a troublesome condition.

This mule stand operates in a pulp mill in an atmosphere filled with condensed steam which keeps the belt dripping wet continously. Belts which absorb moisture either stretch or shrink and on one occasion another belt on this drive shrunk to such an extent as to break loose the drive shaft. This 5-ply, 10-in., extra-heavy rubber belt transmits 50 hp. at a speed of 1,500 f.p.m. and travels over pulleys 26 in. in diameter. These belts last from 14 to 16 mo. and do not shrink nor stretch. Previous belt installations averaged only a few months in service. This installation was made by The B. F. Goodrich Rubber Co., Akron, Ohio.

of the proper size to give sufficient space between the end of the belt and the rivet so as to decrease the likelihood of the fastener pulling out when the belt begins to age.

Mill Bearings and Their Lubrication

Because bearings and their lubrication are mentioned third in the above list of the three most important types of equipment which require the attention of the maintenance and operating departments does not indicate that they are third in relative importance; generally a failure in any of the three elements affects more than merely the unit which has failed.

Bearings have to withstand considerable hard usage in a mill, especially when subjected to abrasive dust in the air. Also, they are often placed in out-of-the-way corners where their lubrication is neglected. A trip through many mills would disclose places where a grease cup was probably installed when the bearing was put in, but it is now operating with no provision for lubrication because the cup came off and has not been replaced. All bearings should be looked over at regular intervals, cleaned and taken up where needed. On a bearing operating at comparatively high speed I favor the pin-cup type of lubricator, which is merely a cup with a copper wire soldered on to the cap and allowed to trail on the shaft. The heat caused by the friction of the wire on the shaft melts a little of the grease and allows it to form a film around the bearing. The use of any grease which may be on hand will not give the best results unless the grease is meant for that type of bearing. It is particularly advisable to obtain the proper pin cup grease for use with a pin-cup type of lubricator.

The Use of the Pressure System in Mill Lubrication

Probably one of the best methods of lubricating the general run of mill bearings is by the grease gun pressure system. Sufficient power may be applied with the gun to force the grease into the bearings and on through to form a collar of grease around the outside that will prevent the entrance of dust and abrasive substances between the shaft and the babbitt or other bearing metal. One of the common mistakes made in connection with the use of a grease gun is to use it too infrequently.

In the case of ring-oiling pillow blocks or bearings, care must be taken to see that the rings are revolving with the shaft and also that the oil is changed periodically. A pocket flashlight can be used to inspect the rings in the bearings to see if they are turning. On some types of mill machinery a saving can be effected by using the oil drawn off from the crankcases of trucks and automobiles; it is, however, best first to strain it through a flannel bag to catch bits of metal and so on. The small amount of gasoline that is present will do no harm as it thins out the heavy oil. Bearings, so lubricated, however, need to be watched very carefully. It is not advisable to use this oil on motors, special machinery, reduction gears, or on equipment where the manufacturer specifies a particular grade of oil. In such cases, it is often poor economy to depart from the specifications, as the maker of the machinery has usually experimented until he can recommend the lubricant that gives the best results.

With the heavy machinery around the mill, such as kiln gears, crushers and so on, there is often a tendency to apply a too generous supply of oil or grease; this results in an untidy and dirty machine and often a slippery and hazardous floor. To prevent this the oiler should be instructed as to the quantity of oil to use, particularly so in the case of bearings with an overflow. I have tried the plan of giving an oiler a definite quantity of lubricant, which was considered sufficient for his shift, and telling him that there would be no more forthcoming; he usually ends up by having some left over. However, there is danger of his neglecting bearings occasionally. If he is an old employee and has been on this work for some time this plan can be tried out and will most likely work satisfactorily.

With heavy gears and pinions, a grease that has to be warmed up and applied with a brush once or twice a day is an economical lubricant to use, as it does not collect so much dirt and carry it around with the gears.

In addition to motors, belts, and bearings each industry or mill has certain types of machines which require considerable attention. This article will discuss the maintenance and operation problems in connection with various pieces of equipment.

Bucket elevators, for example, are found in a wide variety of industries and are a type of machine that requires close care and maintenance. In fact, many engineers are prejudiced against bucket elevators because their maintenance cost is high. This high cost, however, is

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generally due to allowing the elevators to run as long as they will without attention. Experience has shown that in a mill where space is an important consideration, the bucket elevator, if properly cared for, is no more expensive to maintain than any other machine, if it is the right type of elevator for the work and is used properly.

The cost of improper use is well shown by the following example. In one mill, ore had to be elevated from a trommel screen to a feeder bin. An old, discarded, vertical bucket elevator was impressed into service. In order to get the heavy ore to discharge clear of the elevator head, the speed had to be increased far above that at which it was intended to operate. This resulted in a correspondingly increased wear and tear on all parts. Costs of the work done on this elevator, including the maintenance, were kept for the year and reached a total that would have gone far towards remodeling the arrangement and also towards installing an indirect continuous elevator that would have, with proper maintenance, given good service with a minimum of trouble. On this same installation, an extra bin was built in to be fed by this elevator. This also required the addition of a small conveyor on top of the bins in order that the ore could be distributed as required. All this could have been avoided by putting in the right type of equipment in the first place and having a bifurcated chute to each bin.

The installation shown at the bottom of page 572 was more expensive to install than was necessary. In this case two motors are used to drive a trommel screen and a small roll. However, one motor driving a jackshaft would do the work as well. Although group driving cannot always be advocated, there are conditions, as here, where it can be used to advantage, because on this installation if one piece of machinery happens to go down the other must be stopped.

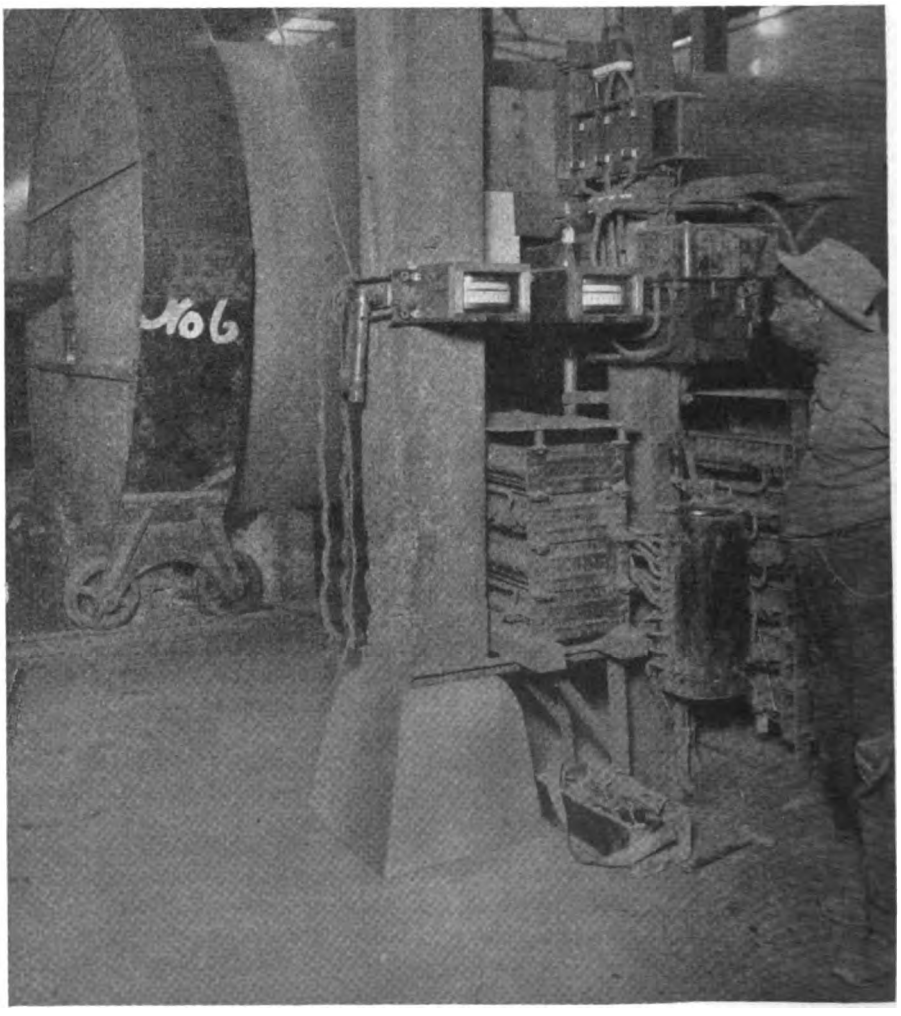
The handling and storing of tools and supplies for the maintenance department is not always done effectively. Often there is no system at all; each man is supposed to have his own tools, and these are frequently in a much neglected condition. The first thing to do to improve this condition and put in some sort of system, is to collect all tools, good and bad, and place them on a tool account.

Problems in the Handling of Tools and Supplies

Plants which have a toolroom and stockroom for the production department can sometimes issue special tools and supplies from it to the maintenance department. However, some provision must be made so that the maintenance workers can get at their tools and supplies on Sundays, at night, or at any other time. Large maintenance organizations can keep their own toolrooms and supply stores. The small plant may find this too expensive.

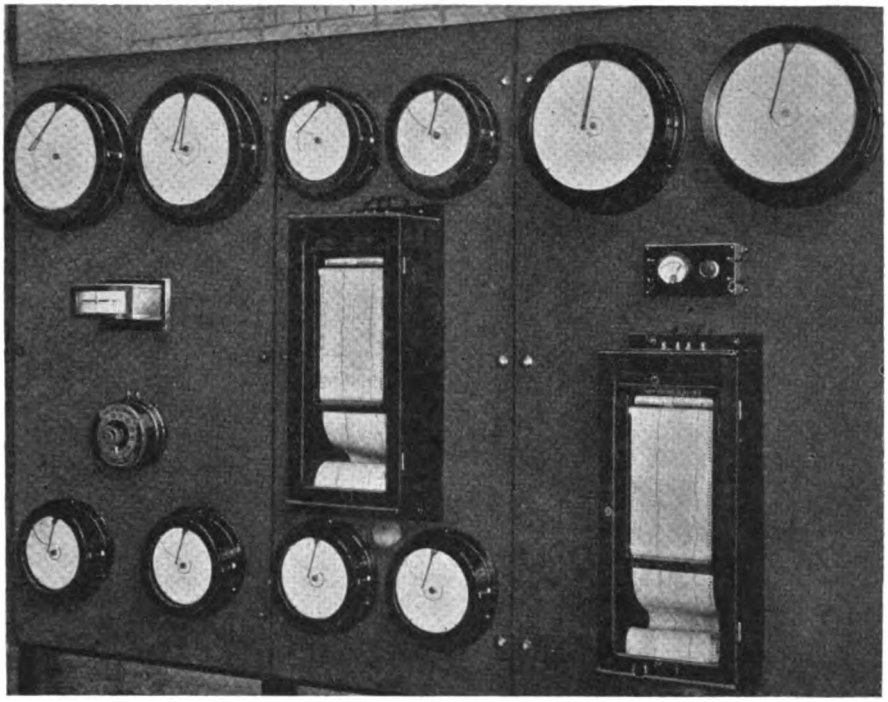
A plan which the small organization can follow is to build tool and supply lockers at different places around the plant. For example, one locker might be placed in the machine or repair shop, others in various places in the mill at some distance from each other, and one or more outside for bars, shovels, and so on. Each of these should be stocked with the tools that are considered necessary in the various locations. In the mill, for example, this locker could contain a hammer, several chisels, three big wrenches and any of the special tools that may be needed for the particular equipment used. The machine shop will need a larger selection and the tools for the outside locker will have to be selected as may be needed. Keys to these lockers should be given only to certain men, who should be held responsible for seeing that the tools are in their proper places and that they are taken care of.

Before putting these tools in the lockers they should first be put in good shape by renewing handles, when necessary, putting new jaws in wrenches, and so on. Tools that have worn out beyond repair should go to the scrap heap, as nothing is more troublesome than for a man to find himself on a job, especially in an awkward place, where his wrenches will not grip or his chisel will not cut. Any extra or expensive tools, or other equipment,



Indicating and recording instruments can, if properly used, do much towards reducing the maintenance and operating costs of kilns and other equipment. These Brown indicating pyrometers are installed at the kilns of the Pennsylvania Cement Co., Nazareth, Pa.

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A typical installation of instruments in one plant.

This installation of indicating and recording instruments indicates a convenient arrangement of meters which might be used to show the consumption, pressure or other operating conditions at various locations or departments. This installation was made by the Brown Instrument Co., Philadelphia, Pa. As explained in the accompanying article, it is not advisable to turn valuable instruments such as these over to anyone to take care of, as they can easily be put out of order. The danger of this is greatest in the small plant where there are only a few instruments to be looked after.

should be let out on a tool check or put under the direct charge of the foreman.

It is not necessary to put in an elaborate and complicated check system: this can be as simple as possible; all that is needed is to know who has the tool. In a small organization all that would be required is to have a place for every tool, either in a drawer, or hanging up, with a numbered tag on it. Numbered checks corresponding to his card or time clock number, should then be issued to each man, for which he signs a receipt; on drawing a tool out, his check is placed on the tool hook. This method shows at a glance what tools are out and to whom they have been issued. When a man quits, he must first get a tool clearance before he receives his pay. Replacements of broken tools should be made only when the man turns in the broken parts: lost tools should be replaced only on the authority of the foreman. The above outline is merely a guide, to be modified or enlarged as necessity or occasion demands.

Maintenance work on the building and yard also comes under the supervision of the maintenance department. Among other activities the woodwork, such as framing, bins and runways, and so on, should be given periodical coats of paint, or better still, be painted with a so-called fireproof paint. In many localities the insurance rate is materially affected by this precaution. Also, there should be sufficient fire hydrants to enable hose lines to be brought to any part of the plant. A supply of hand fire extinguishers should be provided, which must be inspected and refilled periodically. Fire-fighting apparatus must be systematically overhauled and disciplinary measures taken with anyone using fire hose for any but the proper purpose.

Pumps are another piece of equipment common to all industries which are often very much neglected as long as they function. The careful mechanic will see that all lost motion is taken up, the valves packed, and the pump kept clean and in good working condition at all times. One often wonders how the old reciprocating pump, that is usually tucked away in a corner, performs the work that it does, considering the little attention it gets. However, there is always a last straw that breaks the camel's back and when the almost forgotten pump is called upon for an emergency, it fails and all through the neglect of a little timely maintenance.

The writer has been around many small plants, where as long as the equipment keeps going, no one worries about maintenance, and where the sight of good machinery being ruined for want of attention is almost akin to criminal neglect. The need of the application of more modern maintenance practices is very apparent in some small mills. It would be well for some of the heads of these plants to follow the example of the big factories, where proper maintenance is one of the mainstays of the organization, instead of being inclined to sneer at the "new-fangled ideas," as is so often the case.

Many good ideas come from the man on the job and are worth looking into. One way to get these ideas is through the suggestion box, by offering a small reward for workable ideas. This is being used with good results by some of the most successful plants in the country.

How Charts and Records Help Operation and Maintenance

Control of maintenance, operation and production is probably best kept by a study of charted records of everything that goes on. This can be done only by having a complete record of the why and wherefore of every change in operation. Unfortunately, in many good mills no record is kept of the different factors that govern production, and no consideration is given to the importance of having a reliable check on these factors that really determine production and operation costs. Where pyrometers are in use it is often advisable to use recording equipment. The continuous record of operation that the charts give may show very plainly where saving in fuel or improvement in quality of the product may be made through accurate control of temperature, better scheduling or handling of work, and so on.

The value of electrical recording instruments, when intelligently used, speaks for itself, especially when power is being bought and such nightmares as maximum demand have to be watched closely. Also these records tell an interesting story to the maintenance organization of the condition of the equipment and the machinery it drives.

The charting of the factors bearing on production are so numerous, differing with the type of operations, that it is not possible to give

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any sort of a comprehensive list of what should be dealt with; these must be chosen with regard to the information desired. Information gathered in this way shows a plant manager at a glance what is taking place and what the cost of different items is. A small plant does not need a complicated system; one that shows the prime factors of operation and costs, is all that is required. However, some plants go so far as to have a staff working on these records all of the time and have the results printed and used as the main record of the plant.

Recording and testing instruments must be taken care of if they are to work properly. Although the small mill cannot afford to have an instrument man such equipment should be put under the care of some one person, because it is not advisable to have everyone prying into an expensive meter with a cold chisel. The head electrician in the small plant is usually as good a man as any to handle the instruments. In any case, all delicate instruments should be kept locked and only one man have possession of the keys. Instruments should be housed in a dustproof cabinet, away from all vibration, and where they are not likely to be injured by falling objects.

To get better care of the instruments is not the only advantage of keeping the cases locked. For example, in a mill using heat-recording instruments, the night shift boss once turned in a chart showing a very fine record of control of the steam during the night. Unfortunately for, and unknown to him, the clock mechanism had been removed on the previous shift for repairs. It is seldom advisable to have the man who is responsible for the record supervise the instruments and remove the charts.

To be of value, charts from recording meters must be systematically filed where they can be easily located for reference, and not just piled out of the way in some corner. If a firm goes to the expense of buying valuable instruments, any money spent on their care and on the methods of extracting the most value from them, is well spent.

A record of steam or fuel oil consumption, where used in a process, is almost a necessity, as it gives probably the most vital factors of production. An accurate record, when checked against what was thought to be an intelligent guess, is likely to be an eye opener. For example, in one case a meter was installed in the fuel oil line to a kiln. No record had been kept beyond jotting down the amount supposed to be in the tank car. When checked by the meter it was found that the car did not always contain its full quantity. Further investigation disclosed a considerable amount of water with the oil. Also, records of production at different temperatures indicated that as good results could be obtained at a considerably lower heat, with a correspondingly decreased fuel oil consumption.

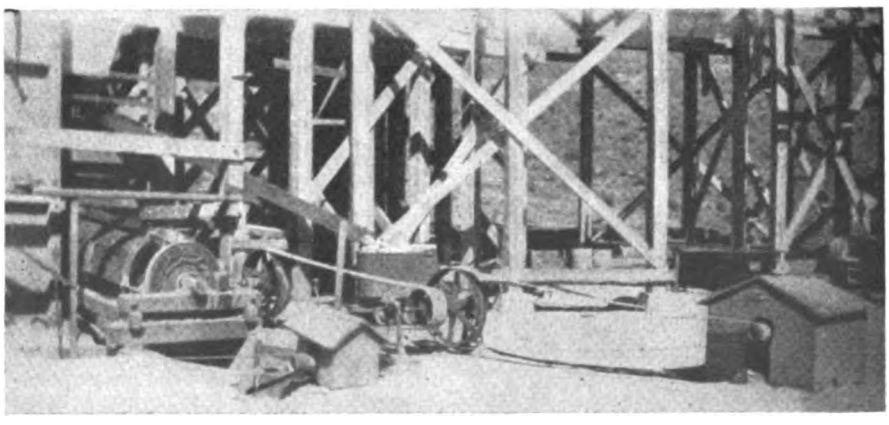
Why the Small Plant Cannot Neglect Maintenance

Because a mill is small, and with new equipment running smoothly, is not a condition that should permit maintenance to be neglected. If nothing is done the time will come when extensive repairs cannot be avoided, and often must be made when they will interfere most with production. The far-seeing superintendent will, before this time, have his millwrights and electricians constantly looking for trouble, because in a mill the best way to avoid trouble is to look for it, instead of relying on the time-honored method of not troubling equipment until it troubles you. Needless to say, when equipment which has been neglected in this way does begin to cause trouble it usually seems that the trouble begins to happen almost everywhere at once.

Plants which have tried out the plan of giving careful attention to equipment to see that any of the miscellaneous little things, which, if neglected, will cause trouble, find that this plan more than repays itself through decreasing breakdowns, interruptions to service, and interferences with production. The cost of a repair is much more than merely the cost of the time of the maintenance department and of the material used, if the men in a large section of the plant are waiting idle for the equipment to start up again.

The number of men and the extent of the organization of a maintenance department in a small plant depends upon its size and type and the amount of work to be done. Sometimes a man or two with all-around experience constitute the nucleus of the departmental organization with the superintendent or his assistant directing the work. Increases in the force for special jobs are made by taking a helper from some other department or hiring a man temporarily.

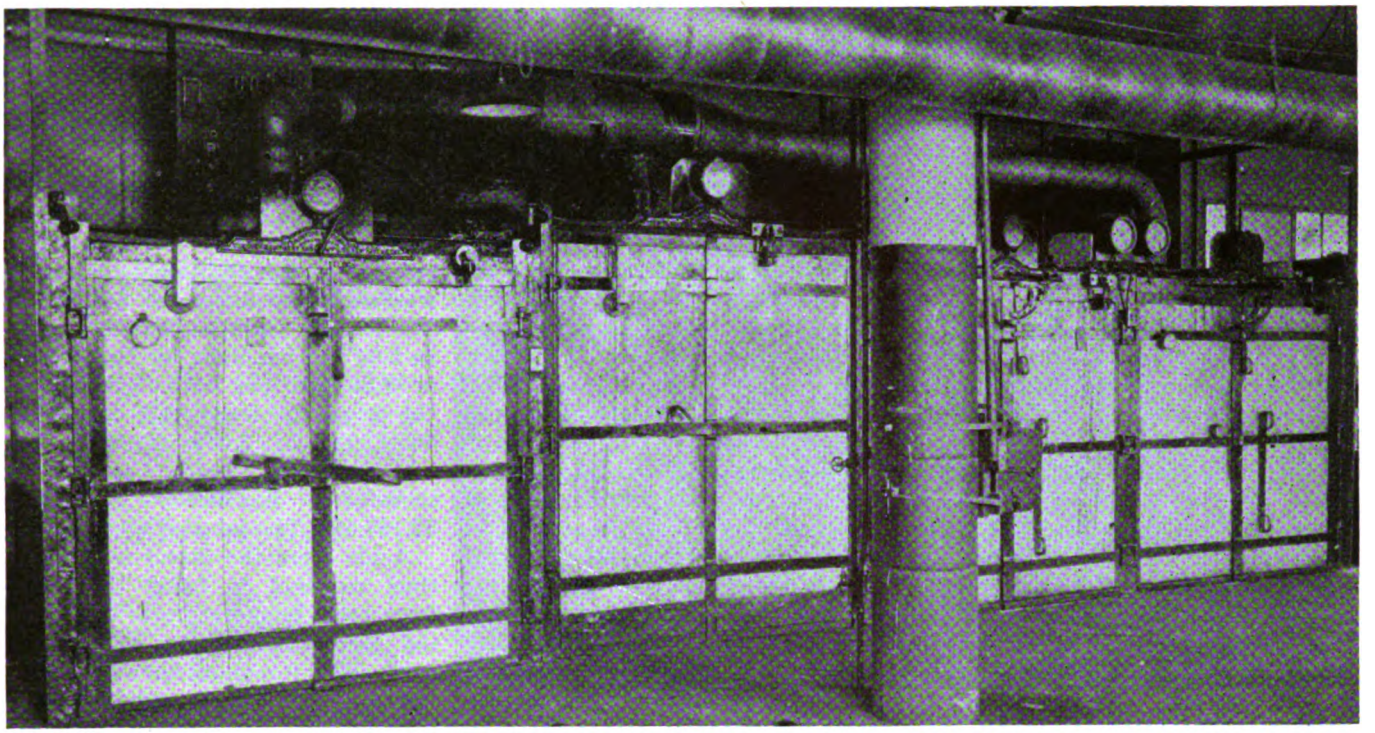
These men, whether primarily electricians, millwrights, or steamfitters, should be instructed in the difference between the maintaining and the repairing of motive equipment and its associated connections. They should be encouraged in the reading of technical journals bearing on their occupation and their industry. One way of doing this is for the firm to subscribe to a few good journals, and distribute them among the various departments with the suggestion that the men mark articles of interest and discuss them thoroughly with the man who has supervision over their work. Reading publications dealing with an industry or with special classes of work is one of the best methods an industrial man has to keep abreast of new developments and applications of equipment.



The answer to the question of whether to use group or individual drive depends upon the operating conditions.

In this case of a mill feeding a screen each is driven by an individual motor. Because neither can operate without the other, it would have been more economical to use a single motor connected to a jackshaft to drive the two pieces of equipment.

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This view shows the four electrically-heated japan baking ovens after they had been installed in one group and additional heat insulation applied to reduce the radiation losses, as explained in the text.

Here is an instance where

Reducing Heat Loss from Electric Baking Ovens

resulted in a yearly saving of $2,200 in operating costs on an installation of four ovens, at a cost of $90 for labor and material

By C. D. CORWIN
Works Engineer, Corona Typewriter Co., Groton, N. Y.

RECENT rearrangement of our baking ovens and some comparatively inexpensive alterations, based on the results of an investigation, rendered it possible for us to make a very much worthwhile saving in the cost of operation. These ovens, of which there are four, are employed for baking the varnish or japan finishes on our typewriter parts, and are of a type commonly used for this purpose. Three of the ovens originally had the following outside dimensions: Height from floor to top, 6 ft. 5 in.; depth from front to back, 6 ft. 4 in.; width 6 ft. 10 in. The fourth oven had a height of 7 ft.; depth 6 ft. 4 in.; width 6 ft. 5¼ in.

The walls of each oven are constructed of black sheet iron inside, backed by sheet asbestos, with room left for air spaces, and have a sheet galvanized iron external casing. The thickness of the walls was about 3 in. The ovens are of the sectionalized type and due to this construction may easily be taken apart and reset should occasion require it.

Gasoline gas was originally used for heating them, but in 1916 this was abandoned in favor of electric heat. The heating coils and controls installed at that time were made by the General Electric Company. In addition, the ovens are equipped with Schaeffer and Budenberg recording thermometers, Tycos heat controllers and mercury thermometers.

For several years, the ovens were located separately at various places in the finishing department, but by reason of a general rearrangement of all of the equipment in this department, it was found feasible to place the four ovens in a row, as shown in the illustration at the beginning of this article. This grouping facilitates the handling of work in process and also gives a much better appearance to the department.

Appreciating the fact that electric heat is costly and that wasted heat represents dollars, a study was made in order to determine the radiation losses from the ovens.

The first tests consisted of permitting each oven and regular load to reach the operating temperature of about 400 deg. F. and then measuring by means of recording and indicating kilowatt-hour meters the energy input required to maintain the ovens at the working range of 350 deg. F. to 400 deg. F.

Part of the energy supplied to an oven is lost by the heat contained in the circulating air which passes out the uptake stack; another part passes to the floor and is carried away by conduction; while a third and greater part is lost by radiation from the walls and tops of the ovens. The object of our study was to reduce this radiation loss.

During regular production as well as during the tests mentioned above, the temperatures at various points on the sides and tops of the ovens were taken by means of mercury

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thermometers immersed in oil. It was found that an average temperature of 170 deg. F. existed on the outside of the walls, 190 deg. F. on the doors and 190 deg. F. on the tops of the ovens. The room temperature is usually about 70 deg. F.

An exact radiation factor for sheet galvanized iron was not available, but for our purpose it was thought that sufficiently accurate results could be obtained by assuming a factor that closely corresponds to one used for cast iron painted with aluminum bronze.

This factor for flat surfaces and for a temperature difference of about 100 deg. is approximately 1.9 B.t.u. radiated per square foot per degree difference in temperature.

Computing the B.t.u. lost by radiation gave results indicating a total loss of 160,735 B.t.u. per hour for every hour that the ovens were actually in use. As one kilowatt-hour is equivalent to 3,415 B.t.u. this represented a loss of 160,735÷3,415 =47.07 kw. hr. At a power cost of $.035 per kilowatt this loss amounted to 47.07×$.035=$1.65 per hour for four ovens, or approximately $.41 per oven-hour.

The actual oven-hours per day vary somewhat throughout the year, but will average about 20 per day, 300 days per year. According to these figures radiation from the ovens was causing a loss of 300×20 ×$.41=$2,460.00 per year.

In order to reduce this loss it was apparent that more or better insulation was required. The location of the ovens was such that their backs, after insulating, would form a partition between a hallway and the oven room proper.

Simple tests were made to determine the relative heat conductivity of Pyrobar. This is a gypsum-base product used extensively for partitions which carry practically no loads. These tests demonstrated that the heat conductivity was very low and as this insulation was to be finished with plaster on the hallway side, Pyrobar blocks measuring 12 in. by 24 in. by 4 in. were used.

Considerable old, air-cell pipe covering was also available and this was flattened out and placed against the outside walls of the ovens so as to form a layer approximately 1 in. thick. The Pyrobar blocks, laid in cement-sand-lime mortar, were placed against this.

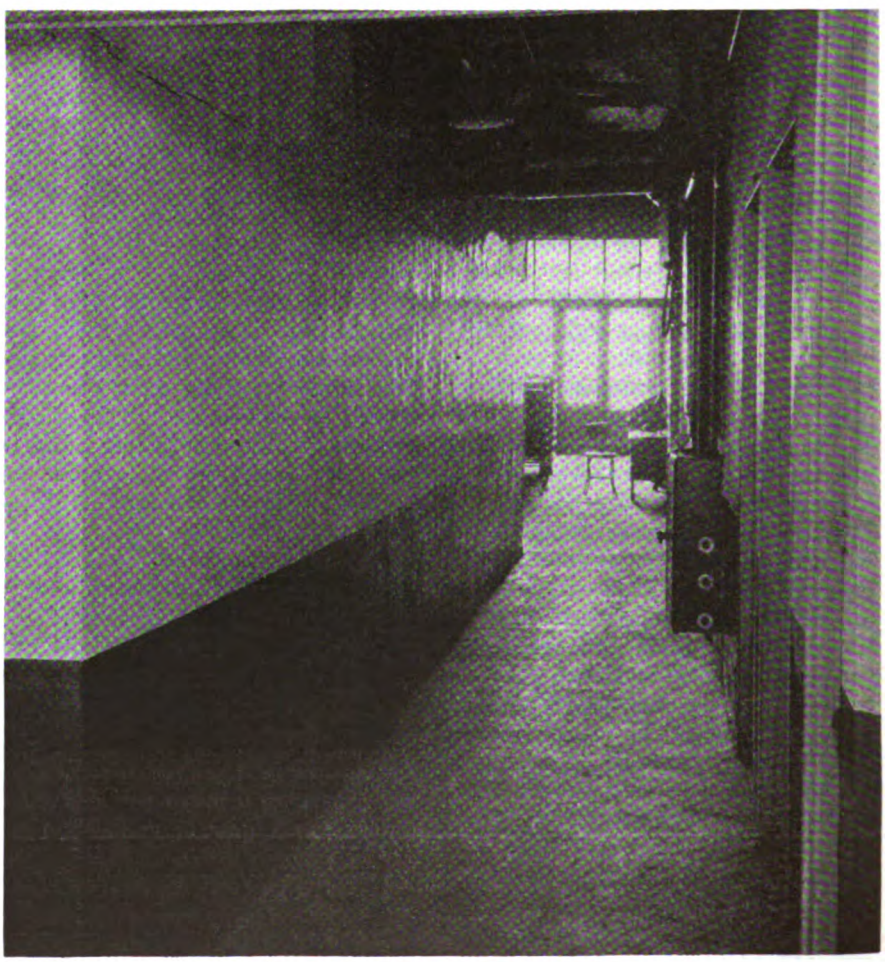
The ovens were reset so that there was, on the average, about 1½ in. of space between them. Inasmuch as we do not always operate all of the ovens at the same time, we filled the space between them with scrap, air-cell insulation mixed with asbestos-fiber cement.

On the hallway side the insulation was given a scratch coat and a finish coat of plaster and then painted to match other partitions in the factory. A rear view of the ovens is shown in one of the illustrations. The tops of the ovens were covered with asbestos-fibre cement, making an insulating coating approximately 3 in. thick. The doors were insulated on the inside by a 2-in. sheet iron envelope packed with the asbestos-fibre cement.

We allowed a week for the insulation to dry out thoroughly before measuring the heat loss. Another test then showed that practically no rise in temperature took place on the side-wall surfaces. The doors showed a temperature rise of 30 deg. F., due quite largely to the fact that their construction was such that continuous metal existed in many places from interior to exterior surfaces. The tops of the ovens showed a rise of about 15 deg. F.

For a 30-deg. rise the radiation factor is 1.55 for flat surfaces; as these are so close the loss after putting on the additional insulation was computed using the factor 1.6. The loss by radiation was figured to be 5.04 kw. per hour for four ovens, or 1.26 kw. per actual oven-hour. On a yearly basis this would be 300×20×1.26×$.035=$262.50. The net estimated yearly saving is, therefore, $2,460.00 — $262.50 = $2,197.50. The job cost about $90.

Aside from the direct saving the time required to bring the ovens from room temperature to the working temperature was also shortened. The foregoing shows the saving on a relatively small baking installation. The quantity of heat wasted in baking and similar operations in industrial plants is undoubtedly quite large and in many instances a little thought and planning will make possible a saving that is many times greater than the necessary investment.



The backs of the ovens form one side of a hallway leading into the finishing department.

After the additional heat insulation had been put on, scratch and finish costs of plaster were applied over it and then painted to match the other walls and partitions.

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Practical advice on

Brush and Commutator Maintenance

including the more important things to watch for and how to go about checking them in case of commutation trouble

By E. S. HOWE
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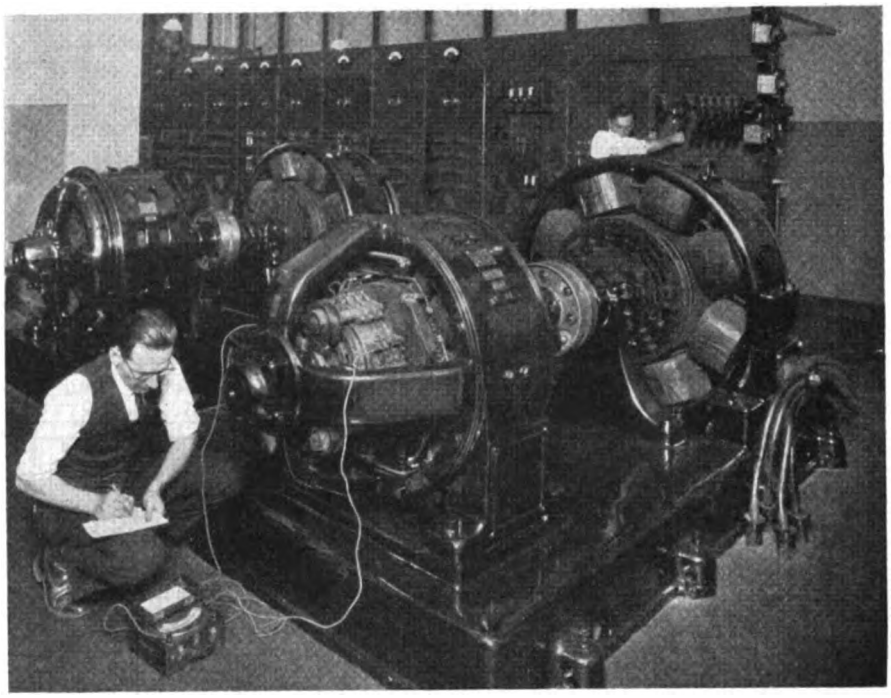


Fig. 1 — Determination of the proper position of the brushes by "kick neutral" is the easiest, although not the most accurate, method. The set up shown here is given in detail in Fig. 4.

SINCE the general adoption of auxiliary commutating poles, great progress has been made in obtaining sparkless commutation under varying load conditions. During this period manufacturers of brushes have made minute studies and analyses of types, grades and qualities of brush materials and commutating conditions. The operating man had best adhere closely to the instructions of brush manufacturers regarding the use and application of the different grades of brushes. There is little to be gained by individual experiments unless it is based on the huge mass of information and experience already collected by the brush manufacturers. There are, however, certain points that may well be considered in an analysis of commutating troubles and which help to make the study a logical one and not a matter of pure guesswork.

Proper Position and Spacing of Brushes Are Important

First of all carbon brushes should be evenly spaced around the commutator. Equal spacing is very important. When brushes fit properly in their holders, the most accurate method of spacing is to pass a narrow strip of paper under the brushes and entirely around the commutator. Paper from an adding machine roll or a few feet from the strip chart of a graphic meter is very convenient for this work. Mark on the paper the position of the toe or heel of one brush on each brush arm. On removal of the paper, accurate measurement will show the actual spacing and what adjustments are necessary for equal spacing. Repetition of the process finally results in exactly equal spacing around the commutator. Or, having determined the exact circumference of the commutator by means of the strip, it may be divided into a number of sections equal to the number of brush arms. The brush arms are then set to the marks on the strip.

Of course, the brush arms must be exactly parallel to the shaft. To check this point, turn the commutator until the brush arm under test has the toe of the brush along a mica segment. Parallel brush edges and mica segments will show immediately that the alignment is correct. If the brushholder studs are not parallel to the commutator segments, the brush span is increased as shown in Fig. 2. This is equivalent to using a thicker brush which increases the short-circuit current as is explained later in the article.

Current should divide itself evenly among the brushes. None of the brushes should take less than its full share, for that would throw excess load on the other brushes. To this end the spring pressure must be kept equal on all brushes. Small spring scales commonly used by amateur fishermen and sold in sporting-goods houses are admirably adapted for measuring brush pressure. The scale should be hooked to the brush or brush pigtail and not to the brush spring. The measurement is made by slightly lifting the brushes, one by one, and measuring the spring pressure directly on the spring balance. This method automatically corrects for the weight of the brush itself. The brushes on the top of the commutator add their weight to the spring pressure, while those underneath subtract their weight from the pressure of the springs. It is not sufficient to measure the force required to lift the spring alone because the friction of the brushes in their holders varies and vitiates any measurement of the spring tension alone.

An old rule for brush pressure was about a pound per square inch of brush surface or, slightly more pressure, if commutation continued unsatisfactory. This was when commutation requirements were not always sparkless from no load to full load and over. Such a lenient rule is no longer acceptable. Brush manufacturers have definite recommendations for pressure for any type and application of brush. These recommendations should be known and applied. Undercut commutators require less pressure than commutators with flush mica. Nowadays a manufacturer may recommend a pressure anywhere from ½ to 7 lb. per sq. in. Crane and railway motors require higher brush pressure than do stationary motors,

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because of the vibration to which these motors are subjected. One brush manufacturer recommends a pressure of 3 to 5 lb. per sq. in. for crane motors and 4 to 7 lb. per sq. in. for railway motors.

Sparking due to high mica might be reduced with brush pressure in excess of the manufacturer's recommendation but obviously the really conscientious operator will not allow himself to be misled by such temporary improvement. He will correct the real trouble; that is, remove the high mica so as to make a permanent correction before abnormal wear takes place on the commutator.

Brushes must be of a size that will fit closely without binding in the brush holders. They must not be too big because then they will stick and not move freely up and down with the eccentricity of the commutator, if any exists, and also because the spring pressure will lose its full effectiveness. They must not be too small because then they will wobble about within their brush-holders, wearing their sides excessively and then naturally wearing new contact surfaces with the commutator. A new contact surface will, until worn in over the whole face of the brush, reduce the area of contact and hence the total commutating capacity of the brush. Furthermore, the slight cavity between the commutator and the part of the suface not yet worn in, becomes a fine pocket for the collection of dirt and the breeding of trouble. So careful attention to the fit of brushes in their holders is paramount.

There is no advantage in having a large clearance between the brush-holder and the commutator. A normal clearance of ⅛ in. is satisfactory. This amount may be varied slightly so as to make the clearance the same on the front and rear of the holder if desired.

The inclination of the brush is another important item for consideration. Inclination varies markedly with the quality and composition of the brush. There is no rule except to use the recommendation of the manufacturer for the carbon brush in question. I remember a rotary converter with unsatisfactory commutation and noisy operation, on which satisfactory commutation, quiet operation and smooth-running brushes were obtained simply by changing the direction of rotation of the armature. This had the effect of changing the angle of inclination of the brushes in regard to the commutator rotation. In short, if trouble exists, one of the points to check is the inclination of the brush used as compared with the maker's recommendations.

Methods of Checking Neutral Position of Brushes

In the older machines the best brush position for any given load was found by moving the brush rigging forward in the direction of rotation with increasing load on a generator, and backward from neutral with increasing load on a motor. Almost all modern machines have commutating poles or interpoles. Such machines require the brushes to remain exactly on the neutral at all loads. In a generator, the auxiliary pole or commutating pole just ahead of a main pole, in the direction of rotation, is of opposite polarity to that main pole. In a motor, the auxiliary pole is of the same polarity as the main pole of which it is just ahead. Proper commutating pole connections for the machines are sometimes permanently made in the factory. More often, since the ultimate direction of rotation desired is unknown, the only permanent connection is between the armature and interpoles. Both are reversed with reversal of direction of rotation so far as connection with shunt and series fields is concerned, but on the other hand remain in the same relation, one to the other. The commutating field connections should be carefully checked to insure that the fields have the proper polarity.

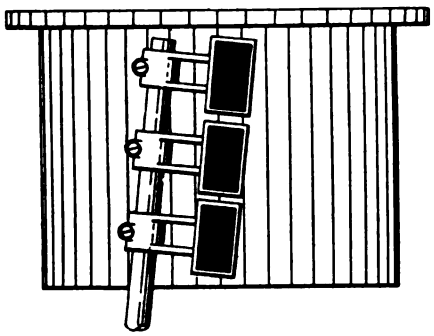


Fig. 2—Brushes must be parallel to the commutator segments.
If the brushes are not parallel to the commutator segments, the effect of greater brush width is produced, as is shown in the figure. This results in increasing the short-circuit current in the brushes, due to the fact that more commutator bars are spanned.

Templets are furnished so that brushes may be reset exactly on neutral, for the larger machines. Even when furnished these templets are often mislaid or otherwise not available and a check is desired to find the exact neutral, so that the brushes may be properly located on the commutator. Four methods are available: the hairpin method, the "kick" method, the two-directions-of-rotation method, and "running" neutral.

For the first method, a short piece of insulated wire is bent to form a hairpin with the ends spread apart about the width of a commutator segment. While the machine is running this hairpin is carried along the edge of the commutator near a brush. The point of least sparking denotes neutral. The brushes should then be moved to this spot and the hairpin again carried along the commutator edge until finally the test shows the minimum sparking to be under the brush. This method is open to the objection that two or more points of minimum sparking might be found and obviously the brushes could not be left permanently in two positions. If there is a hump in the commutating field of the machine, due to an improper interpole field strength, such a condition showing three points of minimum sparking is possible. Fig. 3 illustrates a condition of this character.

The "kick" method of determining neutral is applied without load and with the motor or generator at rest. All the brushes are raised from the commutator except two which are beveled to an edge. The leads from the armature are disconnected from the line. The two beveled brushes are connected to a low-reading voltmeter. The connections for this test are shown in Fig. 4. Full voltage is then momentarily applied to the shunt field and the "kick" or induced voltage is noted on the voltmeter. The beveled brushes are moved as need be until a position is found that shows no "kick" or voltage induced in the voltmeter circuit. This position is neutral and is the proper center line of the brushes. The objection to this method is that any deviation of the mechanical assembly or the magnetic circuit from exact symmetry would render inaccurate the readings at no load.

The third method is more difficult to apply but leads to more accurate results. The machine must be run as a motor during this test. It is run under load while the speed is taken. It is then run in the opposite direction, loaded with exactly the same load and the speed taken

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again. If the two speeds are not equal, the brushes are moved and the two runs repeated until equal speeds are obtained in each direction. The precautions that must be observed are many. The line voltage must be the same during runs in each direction. The temperature of the machine must be the same. The field current must be the same. The bearings must be in excellent condition so as to give no change in friction. The relation or direction of shunt field and series field flux must not change. Equally important, the brushes must fit exactly in the brushholders otherwise they will move and not hold the same contact surfaces during operation in the two directions.

The fourth method of finding neutral, known as "running" neutral, is based on the fact that if the brushes are in the correct no-load neutral position, no voltage will be generated by the commutating-pole flux when the machine is running on open circuit with the commutating winding separately excited. The connections for making this test are shown in Fig. 5. A beveled brush is placed in each of two adjacent brush arms, the same as for determining "kick" neutral. A low-reading voltmeter is connected across these brushes. The commutating field is disconnected from the armature and other windings and arrangements are made for exciting it with from 2 to 4 per cent of full-load current by use of resistors in series with the line voltage. The shunt field is separately excited and arranged with a reversing switch so that the polarity of the shunt field may be reversed at will.

The machine is then brought up to normal speed and by momentarily exciting the shunt field in a reverse direction, the main field poles are demagnetized, until no deflection shows on the lowest scale of the low-reading voltmeter. Any deflection then obtained by exciting the commutating poles will be due to the commutating-pole flux alone.

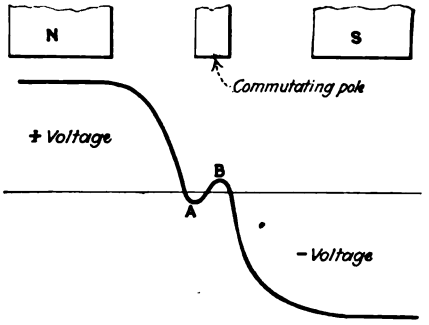


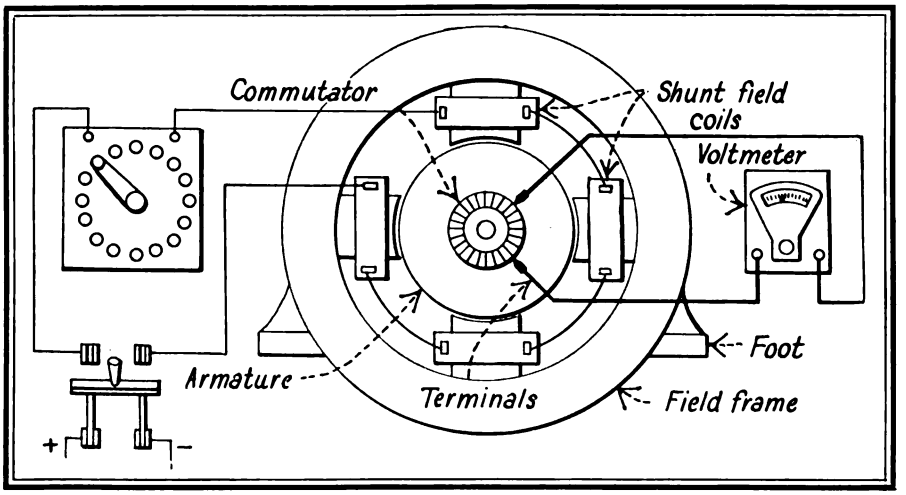
Fig. 3—In some cases the hairpin method of finding neutral will give misleading results.

If there is a hump in the commutating field of the machine, due to improper interpole or commutating pole strength, as at *A* and *B*, three points of minimum sparking at the hairpin may be obtained. The true neutral is midway between *A* and *B*.

Excite the commutating poles with about 2 per cent of their normal current and shift the brushes until no deflection is obtained on the lowest scale of the voltmeter. The residual magnetism in the main poles must be checked from time to time, keeping it at as low a value as possible by demagnetization, as has been explained. After determining the best brush position at the 2 per cent value of commutating pole excitation, repeat the test using about 4 per cent exciting current.

Fig. 4—"Kick" neutral is determined with the motor or generator at rest.

All the brushes are raised from the commutator, except two in adjacent arms. These brushes are connected to a low-reading voltmeter. Line voltage is temporarily applied to the shunt field and the kick or induced voltage noted on the voltmeter. The brush arms are shifted until no kick is noticed on the voltmeter.



If no difference is found, reverse the current in the commutating field and try again, still remembering to check the residual magnetism in the main poles from time to time.

This method gives very accurate results if carefully used. Since the machine is running, errors due to brush resistance or to a brush resting on mica only are eliminated, thereby making this method preferable to the "kick" method.

Modern Brushes Do Not Require Lubrication

Not many years ago it was considered necessary to lubricate brushes to obtain satisfactory results. Undoubtedly the lubrication helped commutation but it brought with it extremely undesirable contingencies. The lubricant worked into the commutator mica and greatly shortened its life; likewise it helped attract dirt which collected under the brushes. Now lubrication is no longer supplied by hand. The necessary lubricant is applied by the brush itself. This lubricant consists of graphite which is a constituent part of the brush. It varies in amount according to the use for which the brush is designed. Brushes for flush-mica commutators need a high percentage of abrasive material to keep the mica worn down and hence less graphite, while brushes for undercut commutators are designed to give minimum wear and so they have a high percentage of graphite or lubricant.

The manufacturers of brushes decide what composition their own brushes of various grades shall have but usually guard the analysis with great secrecy. The operating man must be content with the manufacturer's general description of his brushes and his specific recommendations for their uses. These recommendations are based on long experience and tests. They should be followed very carefully.

Not only is the load current carried by the brushes but in addition the armature coil or coils momentarily short-circuited by the brush as the corresponding commutator segments pass under the brush produce a short-circuit current that passes into and out of the surface of the brush. This short-circuit current serves no useful purpose and the more it can be reduced the better. While the coils are short-circuited by a brush a current will flow in them if they are cutting any lines

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of flux at all. Even though they are then in the commutating zone midway between main poles there still remains a certain amount of magnetic flux, the cutting of which by the coils sets up a short-circuit current. This current is shown flowing around the coil in Fig. 6.

Methods of Reducing Short-Circuit Currents

One brush manufacturer claims for his brush of a certain grade that the resistance crosswise is high and the resistance lengthwise is low. Such an arrangement puts a high resistance in the path of the short-circuit current and a low resistance in the path of the main current.

Another method of obtaining a similar result is to cut a narrow slot lengthwise in the brush, beginning at the surface and rising for a considerable distance into the interior, as shown at *A*, Fig. 7. This slot makes a very slight change in the path of the main current but it materially lengthens the carbon resistance path of the short-circuit current and so tends to diminish that useless current. Another advantage of the slot is the additional radiating surface that it provides. However, the slot has disadvantages in that it reduces the brush surface in contact with the commutator, weakens the brush, and provides a pocket for the collection of dirt.

A third method of reducing the short-circuit current is to reduce the thickness of the brush. This change makes the brush span a lesser number of commutator bars. At *B*, Fig. 7 the short-circuit current is produced by the voltage of two coils in series, while in *C* it is reduced to one coil because there is only one coil spanned by the brush. This third method might not be feasible to adopt because the reduction of brush cross-section might lower the carrying capacity of the brushes to such an extent that they would be unable to carry the required current. Furthermore, reduced thickness of brushes would necessitate new brushholders, which take time and money to obtain and install. A certain modification of this method will ordinarily be satisfactory, but the brushes will require frequent attention. It consists in beveling the brushes on the side where sparking occurs in order to obtain the reduced span at the contact surface, as shown at *D*, Fig. 7. This permits the use of the same brushes and brushholders which were supplied with the machine. The bevel of the brushes must be maintained.

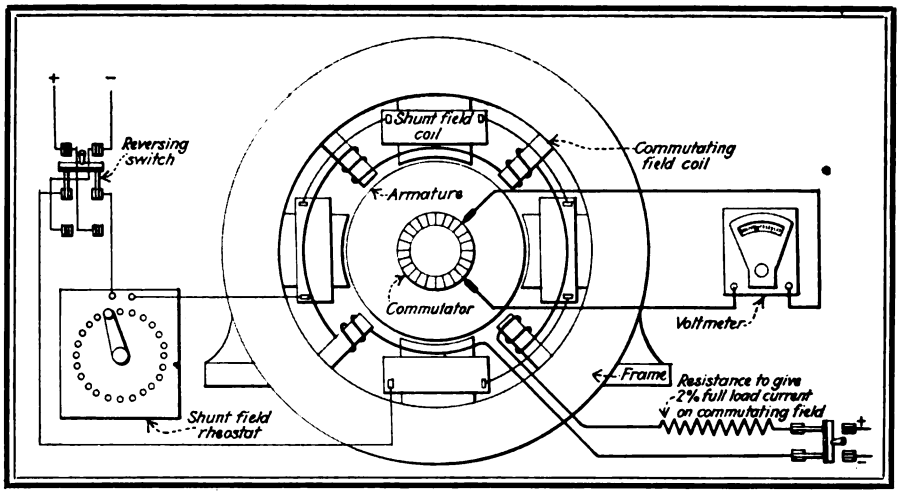


Fig. 5—"Running" neutral is determined while the machine is driven at full speed.
The method shown in this diagram is based on the fact that if the brushes are in the correct no-load neutral position, no voltage will be generated by the commutating-pole flux when the machine is running on open circuit with the commutating-pole windings separately excited.

Selection and Maintenance of Brush Shunts

When it comes to the subject of pigtails or shunts for brushes, the operator of electrical machinery must use his best judgment and depend upon his practical experience. Shunts are made of many strands of small copper wire to give flexibility to the connection between the slightly moving brush and the rigid brush arms. It is essential that the brush be allowed slight movement to conform with the commutator irregularities, so as to obtain good contact at all times and hence give sparkless commutation. To insure this freedom of movement, the flexible shunt best serves the purpose. Its many small copper wires are sometimes made into flexible copper cable and sometimes into braided copper ribbon. These small wires are, however, particularly susceptible to mechanical injury and to oxidation, and should be protected against these whenever unfavorable conditions are present.

Mechanical damage to the shunts is caused for the most part by chafing against other parts of the machine, as for example the brush spring. Stationary machines should have their brushes inspected at the original start-up and the shunts should then be arranged to clear all other parts without any rubbing, and should remain so until the next inspection period arrives. Brushes for more severe service, as in vehicles, may have the shunts especially protected. A number of devices are in common use and may be supplied by brush manufacturers if desired. One way of protecting flexible shunts is to cover them with insulating porcelain beads. Another device consists of a spiral of enamel-insulated steel wire which surrounds the shunt.

Oxidation may be due to moisture, or acid fumes, or may be caused by internal heating due to the flow of excessive current through the shunt. To protect them against oxidation the individual copper wires of the shunt must be tinned. This should be done when the brush is manufactured. If done afterwards the tinning process is likely to make the shunt stiff. With care it is not an impossible task, however, to apply a suitable tinned surface to the shunt.

The terminal on the end of the shunt, which is fastened by a screw to the rigid part of the machine, seldom gives any trouble but in contrast, the terminal that fastens the shunt to the carbon brush is a very probable source of trouble. Conditions surrounding this contact point must be studied and watched by the operating man. These contacts may be all right when the brushes were originally installed but who can say that they will remain so through the normal life of the brush?

A common and inexpensive contact between shunt and carbon brush is made by forcing the end of the shunt into a hole drilled in the carbon and then tamping the hole with a conducting cement. The very general use of this method has proven it to be a successful one. However, when brush trouble arises this point should be carefully investi-

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gated in the various brushes. Obviously the cement cannot be put into the hole under a pressure greater than the breaking tensile strength of carbon and so there is a very definite limit to the contact that can be made by this method. Expansion of the copper of the shunt, the cement that fills the hole, and the carbon of the brush cannot be exactly the same and so brushes of this type that have been subjected to excessive heat or extreme overload may be ruined at the contact point, due to oxidation during undue expansion and contraction.

Installation and Care of the Brushes

In another method the shunt is fastened behind the head of a rivet that passes through the brush. When the rivet is headed over on the opposite end under pressure, heat is also applied to melt the conducting cement or solder around the shunt and the rivet, so that it will make intimate contact with the carbon material of the brush.

This type of contact is more expensive to apply but is stronger than the one described in the preceding paragraph. Its advantages are due to the fact that the pressure applied is limited only by the crushing strength or compression strength of carbon, which is far greater than the tensile strength that limits the first method. Furthermore, the moderate heat used in fastening the shunt insures that the binding material will completely fill all the space between carbon and shunt. Due to the higher pressure used the danger of oxidation during expansion and contraction is greatly reduced.

A few years ago the subject of picking up copper by carbon brushes received much more attention than it does today due, of course, to the fact that it is a much less prevalent trouble today than it used to be. Picking up copper tended to disappear with the reduction in application of lubricants to commutators, and with the introduction of interpoles. Its causes are (1) excessive current passing between brush and commutator; (2) collection by the lubricant under the brush of fine copper particles, produced by the abrasive action of hard carbon brushes; and (3) electrolytic action between the commutator and the brush or lubricant, or both.

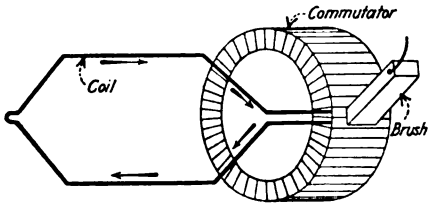


Fig. 6—If the coils short-circuited by a brush are cutting any lines of force, a short-circuit current will flow as indicated. This short-circuit current serves no useful purpose and the more it can be prevented the better.

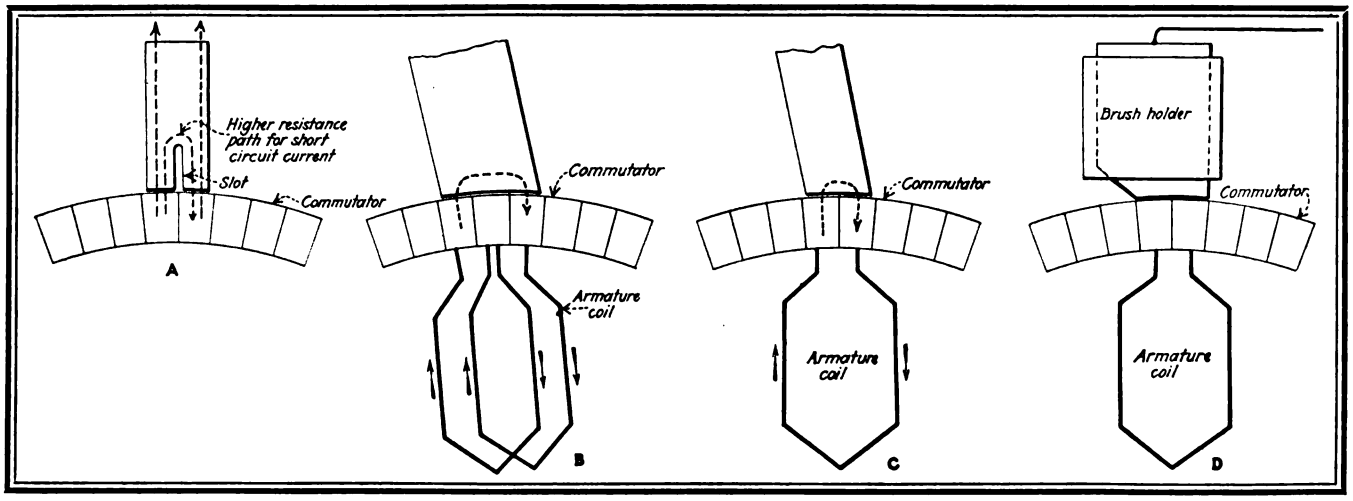
Excessive currents may be due to overload on the generator or motor or, much more probably, they are due to excessive short-circuit currents from the coil or coils short-circuited by the brush. When this is the case, the picked-up copper is deposited more heavily on one-half of the brush surface than on the other, since on one-half the short-circuit current and the main line current are added together while on the other half the two currents are opposed to each other and the resultant current is much less, being only the difference of the two currents. This is illustrated in Fig. 9. With interpoles the short-circuit current is kept within smaller limits and so the brushes are not so prone to pick up copper.

Brushes that are strongly abrasive wear the commutator away in minute copper particles. Some lubricants hold these particles onto the brush contact surface and soon an irregular copper plating is formed. Again, where the brush material and the lubricant form an electrolytic cell with the copper commutator, the electric current developed tends to deposit copper on all of the brush contact surfaces. Because there is a short-circuit current under all brushes there is current flowing from the copper commutator to the carbon brush whether the brush is on the positive or negative side of the machine. As a consequence there is a tendency to deposit copper on the surface of all the brushes. Remedies are found in changing the grade of brush or lubricant. As an example, undercutting the mica would allow the use of a different grade of brush. Also, using a brush composed of a graphite mixture would require no lubrication other than that furnished by the brush itself.

When new carbon brushes are used, they must be ground properly to fit the commutator. If they are sandpapered by hurriedly drawing a strip of sandpaper in one direction and then the other, under the brush, an exceedingly poor contact results.

Fig. 7—Some of the methods that may be used to reduce the brush short-circuit currents, are shown in these diagrams.

In diagram *A*, a slot is cut lengthwise in the brush thereby increasing the path of the short-circuit current. Diagrams *B* and *C* show how a brush spanning more than two commutator bars increases the short-circuit current due to the fact that there are two coils in series. To remedy this condition, bevel the brush on the side on which sparking occurs so as to reduce the span at the commutator, as shown at *D*.



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The carbon brush does not exactly fit its brush holder and with the sandpaper pulled in one direction and then in the reverse direction, the carbon brush moves back and forth in the brush holder by the amount of clearance or play and a composite surface results corresponding to the various positions occupied by the brush. Such a method, although frequently, used gives very poor results.

The proper method is to grind in the brushes by pulling the sandpaper in one direction only, as shown in Fig. 8. The direction of pull should correspond with the direction of rotation of the commutator. In the case of a reversing motor, one of the two directions might preferably be chosen for sanding one-half of the brushes and the other direction for sanding the remaining brushes. One brush at a time should be sandpapered. The sandpaper should be cut into strips slightly wider than the brush. The fingers of the right hand should lift the brush in question 1/16 to 1/8 in. from the commutator. The left hand should then pass the sandpaper strip, with the sand side toward the brush, between the brush and commutator until the fingers can grasp only a remaining inch or so of sandpaper. The right hand should then lower the brush on to the sandpaper strip and apply enough pressure so that the left hand may just pull the sandpaper under the brush through its whole length. The operation is then repeated again and again until the brush surface is ground to conform with the commutator. In order not to round the edge of the brush, the sandpaper must be held at the surface of the commutator throughout the operation.

Maintenance and Care of Commutators

Commutators are built of alternate segments of copper and mica insulation. The thin segments of mica are often held in place between the copper bars with high-grade shellac. The segments are tightly compressed to a permanent position by V-rings of varying design. This compression is applied when the commutator is hot and on larger machines, if the best building methods are used, several tightenings are made between which times the commutator is revolved at its normal speed and temperature. On large commutators especially, the tightening process requires an extended seasoning period. In some cases this period is not terminated until after the machine is installed and regularly operating, so that the operator has to complete the process himself.

The manufacturer will supply information as to the maximum permissible force that may be used with a wrench of given length to tighten the bolts or ring nuts. For a certain type, the total pressure applied to the ring nut should not exceed 20 to 40 tons. If the stretching point of the bolts is reached before the safe working strains of the V-rings, then sometimes gains may be made by substituting hardened steel bolts for others less strong. Likewise, through bolts may replace stud bolts. It is absolutely essential that commutators be made tight or else they will constantly change and give poor commutation. On the other hand, enormous stresses are set up by the tightening process, which are augmented by temperature expansion and the centrifugal force of rotation. The disaster caused by a bursting commutator is serious in the extreme and so operators must never exceed the pressures allowed by the manufacturer.

Bolts must be tightened immediately after the machine has been run at full speed and has attained a commutator temperature of 80 to 100 deg. C. It may be difficult to attain this temperature and various methods may be adopted, such as overload current, bad commutation with brushes somewhat off neutral, enclosure of the commutator, external heating with grids, steam pipes or flames, or friction from blocks of wood. Oftentimes special arrangements are required to stop the machine quickly before it cools after the temperature run.

When the commutator has been tightened in this manner it will be found to have high bars or to be out of round and must be ground. If possible this should be done without current in the commutator. Commutators can be ground when alive by insulating the tool holder. A carborundum stone is a good insulator itself, but emery paper is not. Small armatures can most readily be put in a lathe and revolved at full speed while being stoned. Full speed is essential so as

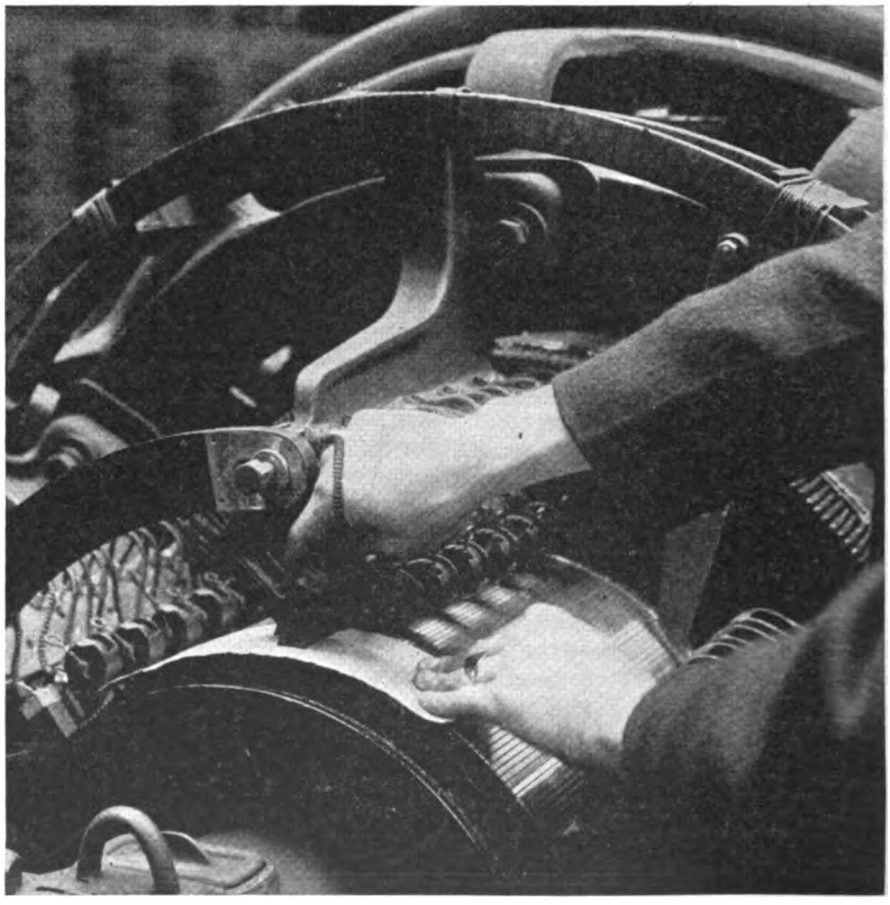


Fig. 8—Points to observe when sanding brushes.

(1) The sandpaper should be pulled across the brushes in one direction only. (2) The direction of pull should correspond with the direction of rotation. (3) The sandpaper should be held against the surface of the commutator, as shown in the illustration throughout the work.

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to simulate the actual operating conditions as nearly as possible.

Grinding Commutator Is Better Than Turning

A little thought will show it is impossible to turn a commutator exactly round with an ordinary lathe tool. The tool will cut through a copper segment with a certain spring. Suddenly it encounters the mica and springs back still more. As it leaves the mica and enters the softer copper, it springs slightly forward again, gouging into the copper. So a commutator turned with a lathe tool has high mica even from the start, albeit very slightly. Such is not the case with a commutator ground true with a stone or grinding wheel.

Usually it is convenient to tie sheets of card board to the risers or armature leads to prevent dust from the stone and copper from getting into the armature winding. A bag is tied under the commutator to catch most of the dust just as it leaves the stone. The stone is applied to the commutator just under the center on the side traveling down. Just below center is preferable because the stone will not stick if excess pressure is applied to it.

Some operators prefer a carborundum wheel of grit No. 70 in place of a grinding stone. The wheel should travel in the same direction as the commutator travels. It is obviously more work to set up a wheel and its rotating mechanism.

A very good stone to use is No. KWR-40 carborundum stone. It is mounted in a tool holder and operated just like a lathe tool. If the beginner will content himself with not trying to force his grinding stone into the work, but will proceed slowly and with caution, he should from the very first obtain good results. He must, however, give careful attention to the finishing methods.

After the commutator has been ground absolutely round, it should be smoothed with carborundum paper, No. 70 grit, and then with No. 00 sandpaper. These abrasive papers work best when pressed against the commutator under a block of wood concaved to the curve of the commutator. After a thorough polishing as it revolves, the commutator will literally shine and reflect like a mirror.

It is now time to undercut the mica. There are several motor-driven tools for this purpose on the market. A good one consists of a tiny circular saw driven through a flexible shaft by a small motor. Ordinary hacksaw blades are the right thickness for mica segments; so a broken one makes an excellent tool to scrape away the mica. As the work proceeds and the end tooth on the hacksaw blade gets dull it may be broken again and a new tooth put into use. No set rule can be given for the depth to cut away the mica.

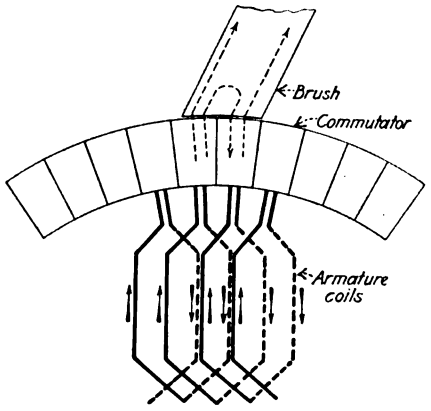


Fig. 9—Copper deposits on the brushes are often due to excessive currents—usually excessive short-circuit currents.

In this case the copper is deposited on the contact surface of one-half of the brush more heavily than on the other. This is caused by the fact that on one-half of the contact surface of the brush, the short-circuit current is added to the load current, while on the other half the opposite is true as shown in the diagram.

The writer has often obtained exceptionally good results by simply scraping away a few thousandths of an inch with a pen knife. For good and lasting results 1/32 in. or 1/16 in. is not too much. Depth of cut is not required for an electrical reason, but rather because it allows a triangular file to properly bevel the adjacent copper segment edges and because it leaves a bigger pocket of air which has a cooling effect on the brush while passing underneath.

There is a theory that mica slots should not be undercut to the extreme outer edge of the commutator because so doing increases the liability of flashovers from the commutator to the front V-ring. On motors or generators that will operate in dirty or oily locations this rule is well applied. After the undercutting is done, a small, smooth triangular file is used to chamfer the edges of the copper bars. Martindale or Keller Bros. commutator files are especially adapted for this purpose. After chamfering, the commutator will require smoothing again. No. 70 grit carborundum paper must be used. Sandpaper is not suitable because it will not cut off the minute copper burrs made by the triangular file. This little item of chamfer, improperly finished, has caused more than one otherwise well-done job to result unsatisfactorily. It must not be overlooked.

Not all commutator troubles originate in the brushes or commutator. A well-known source of trouble is in the soldered joints of the risers from the commutator necks, or of the cross connectors of the armature, perhaps at the opposite end from the commutator. Another source is in unequal magnetic conditions in the various field poles. Still another is in the contact surfaces of the several parallel current paths from the brushes to the common collector. In searching for causes of commutation trouble, it is well to consider that the brushes are in parallel paths and for correct commutation these paths must have nearly equal resistance and magnetic conditions both within and without the armature.

There are other causes external to the commutator and brushes which should be considered when hunting the reason for poor commutation. A common one is an open circuit in an armature coil. Sometimes this may be cured by shorting out the coil, but obviously the more satisfactory remedy is to rewind the armature. Unequal air gaps often cause sparking, the cure for which is to shim up the short poles or grind off the faces of the long ones. Worn bearings are frequently the cause of unequal air gaps. Excessive vibration sometimes causes commutation trouble. This may come from the pound of a reciprocating engine driving the machine, an unstable foundation, or even a poor belt lacing. Short-circuit current between brush studs is usually caused by an unbalanced armature winding. Obviously the best solution in this case is to consult the manufacturer of the machine.

It is well to remember that constant sandpapering should be avoided. Good results are sometimes obtained by simply letting the commutator alone, so it may get its proper, natural finish—a beautiful, deep chocolate color.

Editors' Note: Acknowledgment is made to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., for some of the illustrations used in this article.

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This article explains

What Re-Entrancy Means in Lap and Wave Windings

with some examples and simple rules governing the relations and principles involved in connecting singly and doubly re-entrant windings.

By A. C. ROE
Renewal Parts Engineering Dept., Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.
and
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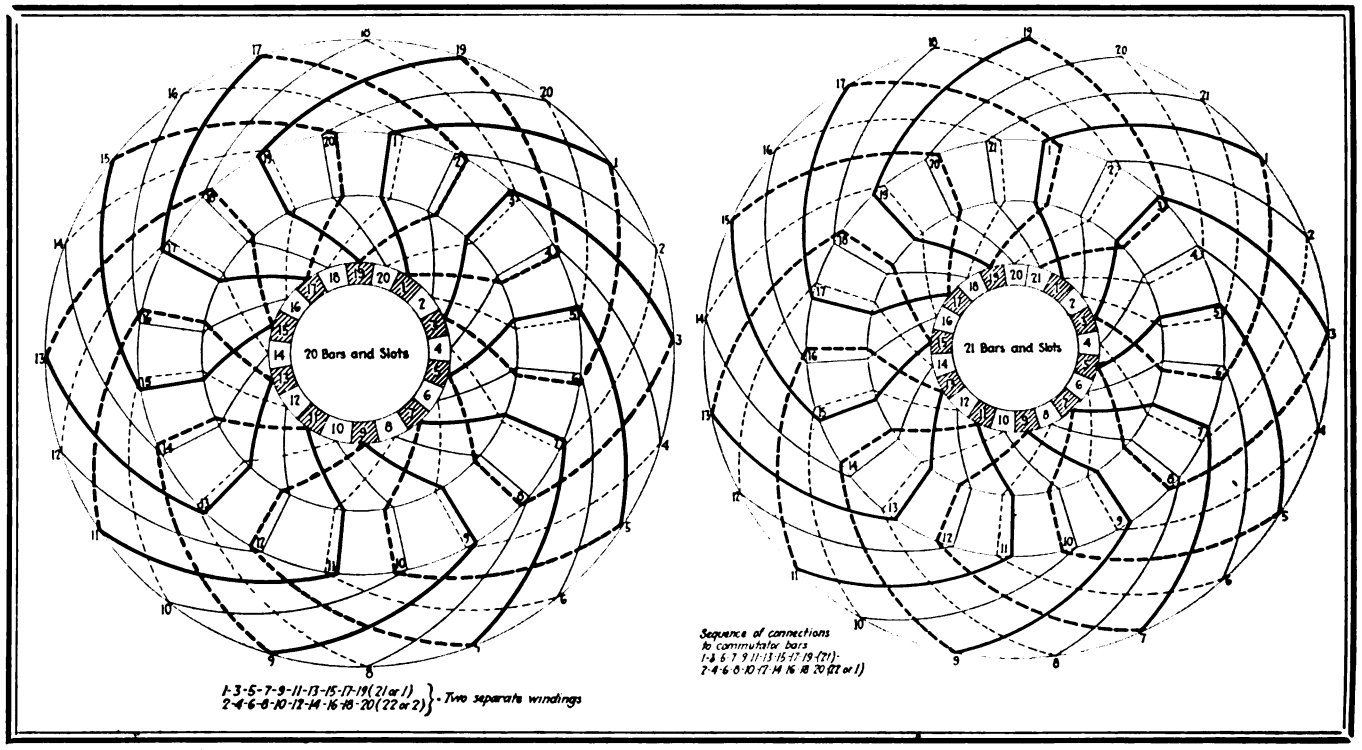
HERE ARE SOME points to bear in mind regarding re-entrant windings:
(1) In all cases, regardless of the number of poles, the winding will be singly re-entrant when the lead pitch expressed in bars, is an odd number, such as 9, 11, 13, etc. The winding will be doubly re-entrant when the lead pitch in bars is an even number, such as 8, 10, 12, etc.
(2) From the above it follows that a singly re-entrant winding is one in which all the coils are passed through in regular sequence before the winding closes on itself, while a doubly re-entrant winding is one in which the winding closes on itself after passing through one-half the coils, thus forming two separate windings which are not interconnected.

TO HELP eliminate some of the confusion in the minds of repair shop men regarding re-entrancy as applied to single and double (or duplex) lap and wave windings, some examples of typical windings and rules for connecting them will be discussed in the following pages.

All single, closed-circuit windings, that is, lap windings in which the top and bottom leads of any one coil attach to adjacent bars, and two-circuit (single) wave windings, where the coils in series are equal to one-half as many coils as there are poles, end on a bar either one bar ahead of or behind the one started on. When the above conditions are fulfilled, the winding will be singly re-entrant regardless of the number of bars.

In a lap winding, when the top and bottom leads of any one coil connect to bars *1* and *3*, that is when there is one bar between the top and bottom leads for any one coil, the winding is called duplex, and will have twice as many paths or circuits as poles. If the total number of bars is an even number, the winding will be doubly re-entrant. Fig. 1 shows a double lap winding (eight-circuit) four poles, with 20 bars and slots, the coil pitch being 1-and-6. The heavy line coils show one winding and the light lines the other winding. When any duplex winding is doubly re-entrant the armature will have two distinct and separate windings. In Fig. 1 the full lines represent the top halves of the coils, and the dotted lines the bottom coil half. In Fig. 1 the top lead of coil *1* connects to bar *1* and the bottom lead of coil *1* connects to bar *3*. Following this path we pick up coil *3*, bar *5*, coil *5*, bar *7*, coil *7*, bar *9*, bar *11*, coil *11*, bar *13*, coil *13*,

Figs. 1 and 2—These diagrams show, left, a four-pole duplex (eight-circuit) lap winding that is doubly re-entrant, and, right, a duplex (eight-circuit) lap winding that is singly re-entrant.



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bar *15*, coil *15*, bar *17*, coil *17*, bar *19*, coil *19*, the bottom lead connecting to bar *1*. Thus, after passing through ten coils, the winding closes on itself, but there is another winding sandwiched in between the first one traced out. Starting on bar *2* and tracing through, we pick up ten coils and end on bar *2*. These two windings do not interconnect and if a test light were placed across bars *1* and *2*, the lamp would not light. If the test were made between bars *1* and *3*, or *2* and *4*, a light would be had. The notation given on Fig. 1 gives the circuit from bar to bar of each winding.

Next, consider Fig. 2 which shows a four-pole lap winding with eight circuits, and 21 bars and slots. In this winding coil *1* is connected to bars *1* and *3*. Starting at bar *1* the circuit progresses to bars *3*, *5*, *7*, *9*, *11*, *13*, *15*, *17*, and *19*, to bar *21* which is one behind the starting bar. Thus the winding does not end on itself, but continues on to bars *2*, *4*, *6*, *8*, *10*, *12*, *14*, *16*, *18*, *20*, and then to bar *1*, which closes the winding after passing around twice. This winding is said to be singly re-entrant.

From the above, the following rules for double or duplex lap windings can be given:

(1) A double lap winding can have any number of bars, odd or even, regardless of the number of poles.

(2) With an odd number of bars the winding will be singly re-entrant. With an even number of bars the winding will be doubly re-entrant; that is, divided into two separate windings.

(3) With a doubly re-entrant winding a light can be obtained, when testing out, only between bars spaced 1-and-3 apart.

(4) With a singly re-entrant winding the windings are interconnected; hence a light will be obtained between adjacent bars, and also between bars spaced 1-and-3. This latter is the correct light-out.

From the above it follows that when taking data the type of winding, that is, whether lap, single or duplex, singly or doubly re-entrant, can be determined by selecting any one coil and top lead, and lifting two top leads on either side of the top lead selected, which can be left in the bar. Then hold one test lead on this bar and try the adjacent bar on either side. If a light is obtained, the winding is single lap, but if a light is obtained on a bar that is 1-and-3 from the data coil lead bar, then the winding is duplex lap and the re-entrancy is determined by the total number of bars, as explained above.

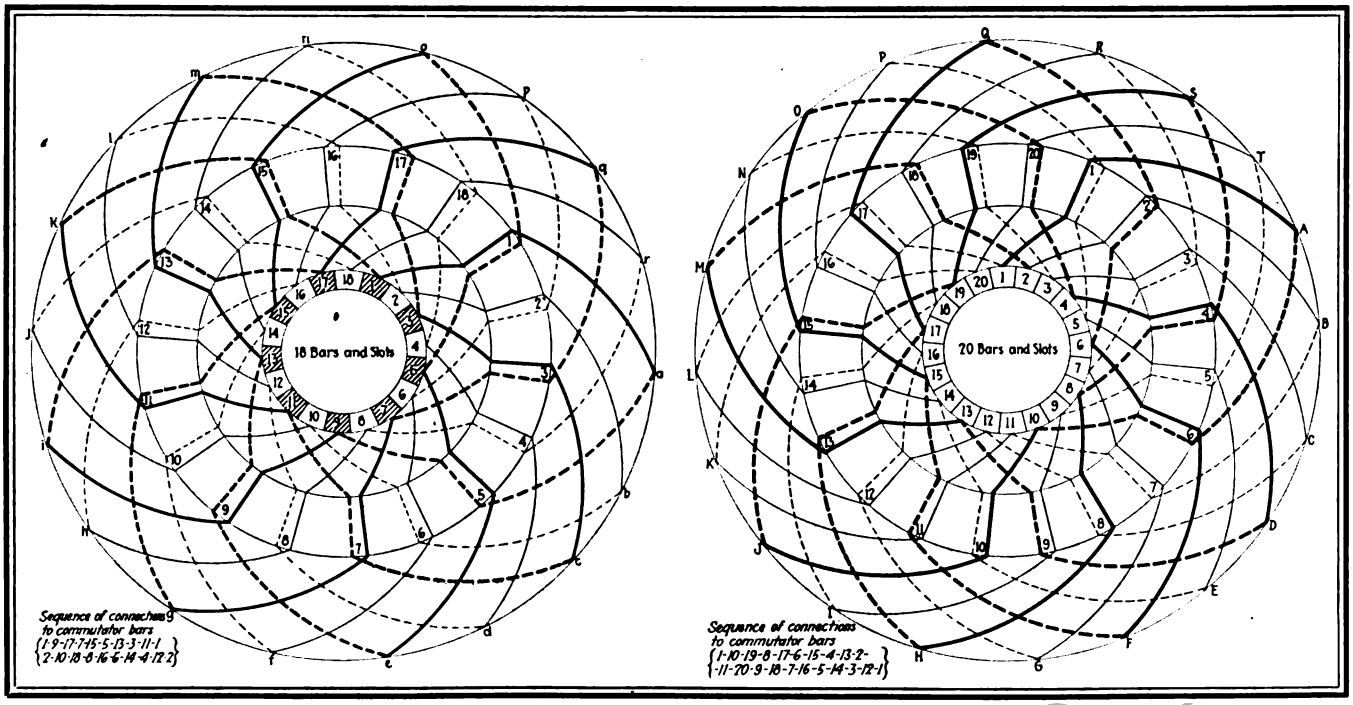
For duplex windings the brushes must be wide enough to cover at least one and one-half bars. The re-entrancy of a winding does not have any effect on the rotation or polarity of a motor or generator.

Fig. 3 shows a double-duplex, four-circuit wave winding, for four poles, 18 bars and slots, coil pitch 1-and-5, lead pitch 1-and-9. For a double wave winding, the total number of coils must satisfy the formula: $L=(B\pm2)\div P$, or the series of P coils must end two bars ahead of or behind the bar that the series started on. Then for Fig. 3 the formula becomes, $L=(18-2)\div2=8$, or 1-and-9, or L could be $(18+2)\div2=10$, or 1-and-11, which would give a progressive, double, doubly re-entrant winding. In Fig. 3 the series of P coils starts on bar *1*, goes through coil *A*, to bar *9*, to coil *i*, then to bar *17*, which is two bars behind the one started on. Note that the heavy lines represent one winding, the bars being marked by shading lines. Continuing the series, we go from bar *17* to coil *q*, to bar *7*, coil *g* to bar *15*, coil *o*, to bar *5*, coil *e*, to bar *13*, coil *m*, to bar *3*, coil *c*, to bar *11*, coil *k*, and thence to bar *1*, or the winding closes on itself after passing once around the armature and through half of the coils. In this case the winding touches only the odd-numbered bars. The second winding starts at bar *2*, and proceeds around the armature to bars *10*, *18*, *8*, *16*, *6*, *14*, *4*, *12*, and back to bar *2*. Two separate windings are thus formed. With a brush in contact with bars *1* and *2*, and also bars *5* and *6*, a four-circuit winding would be indicated.

Fig. 4 shows a four-pole, retrogressive, wave winding having four circuits, singly re-entrant, with 20 bars and slots, coil pitch 1-and-6, lead pitch 1-and-10. Note that this

(*Please turn to page 604*)

Figs. 3 and 4—At the left is a four-circuit, four-pole wave winding that is retrogressive (short pitch) and doubly re-entrant, as indicated by the lead pitch in bars being an even number (8). At the right is a four-circuit, four-pole wave winding that is retrogressive (short pitch) and singly re-entrant, as indicated by the lead pitch in bars being an odd number (9).



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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



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Chicago, December, 1925

The Best Safeguard Is a Careful Man

MEN engaged in safety work in industrial plants generally estimate that it is possible to safeguard against approximately 90 per cent of industrial accidents; for the other 10 per cent the worker alone is responsible. This would indicate that safeguarding alone is not adequate, and that the men must be trained so that they will not only take full advantage of the safeguards and not remove them or evade them, but, in addition, will do their work carefully so as not to endanger themselves or their fellow workers.

The necessity of safeguarding workers by teaching them the careful way to do their work is particularly apparent in the case of men who are engaged in maintenance and operation. These men often find it necessary to remove guards to get at machines for repair or other work in which they may be endangered by the accidental starting of the machine and, in general, they are frequently exposed to unusual hazards.

Foremen in charge of such work should always watch a new man to see whether he is inclined to be careful or reckless in performing dangerous tasks. If he neglects to take the necessary precautions or is otherwise careless, the foreman should show him the safe way to do the work and insist that he practice it.

In no department of an industrial plant is the axiom, "The best safeguard is a careful man," more true than in the maintenance and operating departments.

Healthful Workrooms Make for Efficiency

WORKING conditions in many industrial plants are not always ideal. However, the fact that noteworthy advancements in industrial sanitation and hygiene have been made during the past few years is well shown by the changed attitude of insurance companies toward workers in occupations that were formerly considered hazardous. For example, textile workers were steadfastly refused insurance because the dust was considered to be injurious, and a high death rate from tuberculosis existed among them. In fact, this class was about the last to be exempt from special rating even when accepted. Now the entire force of men and women, of all ages, in big textile plants is being accepted under group insurance.

An investigation made by the Prudential Insurance Company in connection with its group insurance shows that the majority of plants are conscientiously co-operating with health departments and have installed the most modern and effective devices so far produced to protect their workers from the dangers of dust, fumes and gases. Engineering science has been so successful in perfecting mechanical ventilation that there need be little difficulty in finding the proper equipment to meet any particular need.

Poisoned or even devitalized air is now recognized as a fundamental cause of loss to the employer and danger to the employee. Several states have laws requiring exhaust hoods on all machines for the buffing, polishing or grinding of metal, so as to carry away all dust given off in the process.

In the matter of providing exhausts for the removal of noxious fumes and gases, considerable advancement has also been made. Many states have standard regulations for the proper ventilation of factory buildings. For instance, New Jersey has a code of sanitary and industrial engineering standards and all manufacturers and contractors have to file definite engineering plans for the ventilation apparatus before the installations can be made. Window ventilation is not sufficient in workrooms where processes require the use of volatile, poisonous preparations or chemicals. The aim now is to confine vapors and dust at the point of origin, and to remove them to the outer air in such manner as to prevent them from contaminating the air of workrooms.

Apart from humanitarian considerations, money spent for equipment that will conserve the health and increase the efficiency of employees, may be considered to have been put into a gilt-edge investment.

Makeshifts Are Not Intended for Permanent Use

OFTENTIMES the practical man takes pride in pointing out some makeshift of his devising that has served its purpose well. This feeling of pride is, no doubt, frequently justified by the results obtained or the purpose served. However, it does not pay to overlook the fact that in an emergency, when it is of the utmost importance to keep the wheels turning, it may be necessary to make use of devices or expedients that are not worthy of a permanent place in an installation of equipment. Even though such makeshifts have rendered good service, it is seldom advisable to leave them in operation after the emergency is past, or longer than is necessary to secure standard equipment with which to replace them.

By their very nature, makeshifts cannot, as a rule, be expected to have, nor do they have, the same reliability and efficiency that are built into the equipment put out by a reputable manufacturer. He has at his command designing skill and manufacturing facilities

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that no maintenance department or repair shop can hope to equal.

Makeshifts should be considered only in the light and for the purpose for which they are intended: temporary use until they can be replaced with standard equipment. In any industrial plant continuity of production is too important to be jeopardized by the false economy that will permit a poorly-designed and clumsily-built device to take the place of equipment that has proved its worth under the searching test of service.

Do You Need More Lighting Units or Cleaner Reflectors?

THE shortest days of the year are now with us, and it is at this time that the plant lighting system is used most intensively. It has been proven times without number that an investment in adequate plant illumination pays large returns. Yet, are we always getting all that we should from our investment in artificial illumination?

The first requisite of adequate illumination is that there be a sufficient number of lighting units, properly placed. The next requirement is that the light be directed towards the working space; in other words that the least possible amount of light be wasted. It is for this reason that we have reflectors. But the usefulness of a reflector is easily and rapidly lost through the accumulation of dirt upon it. There are undoubtedly thousands of high-grade reflectors rotting away with dirt and rust, without performing the work for which they were purchased.

Approximately 50 per cent of the cost of an industrial lighting unit is in the reflector. Reliable tests on typical installations show that on an average the loss of light when reflectors are not regularly cleaned amounts to nearly 50 per cent of that available when cleaning is done systematically. In other words, half of the investment in a lighting unit produces half of the light.

Failure to clean the reflecting units periodically, results in a waste of not only half of the investment in lighting equipment but also in a loss of half of the light that is actually available.

Complete Data Make It Easier to Answer Questions

MANY delays are occasioned and much time is lost unnecessarily by failure of those who are seeking information on equipment, particularly electrical equipment, to give all of the data needed before an intelligent answer can be given. Manufacturers of industrial equipment, and others who are in position to give advice, are frequently called upon for information which they would be glad to give, but in many instances the data sent are so incomplete that it is very difficult or impossible to give an answer that is anything more than a guess, which is just about as likely to be wrong as correct. Under such circumstances it is necessary to write for additional information. This is not only annoying, but it is a needless waste of effort on the part of everyone concerned.

Thirty years or so ago, when there were comparatively few manufacturers of electrical equipment, and each one produced at the most only a few items, the terms "three-phase motor," "transformer," and so on, meant much more than they do now, when there are scores of manufacturers producing widely varied lines of standard and special equipment designed to operate under many different conditions.

To the manufacturer of a piece of equipment, the data given on the nameplate thereof serves to identify it completely. The nameplate is a key to the essential features of the design and operating characteristics of the device in question.

You will make it much easier for the other fellow to answer your questions or give you advice on any equipment, if you will send him all of the nameplate data, together with any information regarding operating conditions which is necessary to a thorough understanding of the situation.

You Can't Lift Yourself by Your Boot Straps

TRUE executives realize that they can climb higher and easier in their organization through the boosts and co-operation of their subordinates than by treading rough-shod over them. Without the wholehearted co-operation of his men, particularly of his assistants, the man at the head of a department usually has to drag them along with him, instead of receiving an enthusiastic push from them. In other words he is trying to lift himself by his boot straps.

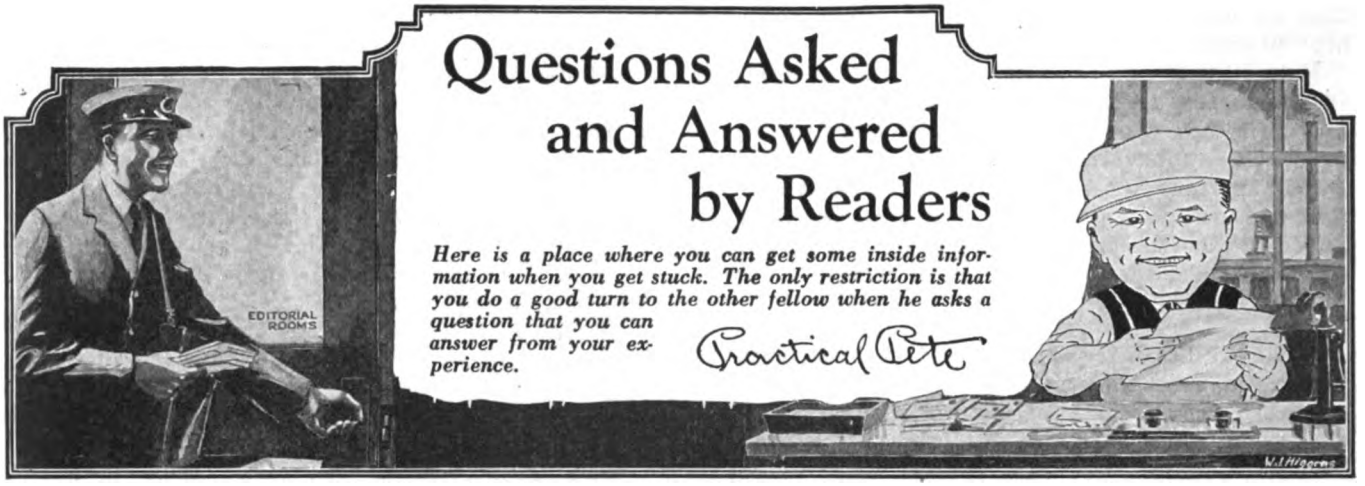
Executives who do not receive a boost from their associates can usually look to themselves for the cause, which most generally is due to a selfish desire to "hog" all of the glory, or to a reluctance to commend a subordinate for work well done. Of these, the former generally causes the more discontent because the superior then usually appropriates as his own the ideas and suggestions of others without crediting the source. Private words of commendation can never compensate for the withholding of public credit for an idea or an accomplishment.

Any fair-minded executive knows that he would think it unfair if *he* were treated that way. His subordinates want to advance also, if he be promoted. Unless a subordinate has received credit from time to time for his accomplishments he is less likely to be considered when an opportunity for advancement opens, and altogether too often an outside man is brought in who frequently has less ability and much less interest in and knowledge of the plant than the old employee. After such an experience it is difficult to get men to co-operate whole-heartedly and offer suggestions and advice freely.

These statements apply not only to the head of a department and his actions toward his subordinates, but as well to the subordinates and those under their direction, and clear down to the man on the job with a helper. Every man appreciates receiving credit for what he does. The leader who gives credit for tasks well done will soon find his men willing to help him, which not only makes it easier for him to advance but builds morale—the stimulant of a successful organization.

Any executive who has the co-operation and support of his subordinates will soon find that he has got a good start on the path to advancement.

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Who Can Answer These?

Ramp for Industrial Truck.—The basement floor of one of our buildings is 4 ft. below the grade level. We are planning on installing an electric storage battery truck for handling heavy material out of this basement and from the yard up to the first floor. What grade should be given to the incline or ramp? Would it be advisable to roughen or ridge the surface of the concrete to give the truck better footing? Part of the ramp will be outside, and exposed to the weather.
Peoria, Ill. S. L. G.

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What Shop Equipment Will Be Required Here?—I would like to have some of our readers tell me what equipment they think will be necessary for a shop to handle a general motor repair business in a city having a population of 50,000. I wish to have as completely equipped a shop as is consistent with the amount of repair work that I may expect to do in a city of this size. Any recommendations as to kinds and makes of equipment necessary will be very much appreciated. Also, I should like to know what kinds and amounts of supplies, such as insulated wire, insulation, varnishes, tapes, etc., should be carried in stock.
Pedro Miguel, Canal Zone. P. F. W.

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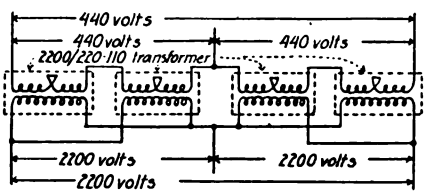
Misleading Results Sometimes Obtained from Magneto Test.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus. Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O. K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?
Omaha, Neb. M. P.

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Is This Lamp Consumption Too High?—Our plant is a malleable iron foundry and our lights are operated from 230-volt direct-current power supply. During the first 314 days of this year, we used a total of 972 lamps in 847 outlets, making an average consumption of 1.33 lamps per outlet per year. To be specific, we used 230, 100-watt type C lamps in 275 outlets, or 0.97 lamps per outlet per year. We used 162, 200-watt type C lamps in 160 outlets, or 1.18 lamps per outlet per year. For portables and extensions at molders' benches we used 600, 50-watt, mill-type lamps in 412 outlets, or 1.7 lamps per outlet per year. The large lamps are subjected to slight vibration due to machinery and lineshafting. The lamps burn 9½ to 10 hr. per day. I should like to know whether other readers think that our average lamp consumption is too high. Also I shall appreciate any information regarding lamp consumption in plants having conditions similar to a foundry, as well as in other types of manufacturing plants.
Chicago, Ill. W. A. B.

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What Is the Capacity of this Transformer Bank?—I have four 25-kva., 2,200/220/110-volt transformers connected to a three-phase, 2,200-volt, power supply as is shown in the accompanying diagram. The secondary of each transformer is so connected that the two 110-volt windings are in series to supply 220 volts. As can be seen from the diagram, 440-volt, three-phase power is obtained from the secondary of this bank of



transformers. I shall greatly appreciate it if some reader will tell me what the capacity of this bank of transformers is with the connection that I am using. I should also like to know the safe secondary line current and also the safe primary line current that these transformers will take with this connection.
Hattiesburg, Miss. J. M. M.

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What Is the Best Type of Drive for This Installation?—I should like to have the advice of readers on the following problem. We wish to operate by a 10-hp., 1,150-r.p.m. motor, a small machine shop and a small reciprocating pump, which are in different rooms, separated by an 8-in. brick wall. We wish to place the motor in the room with the pump. There are three possible drives. (1) Mount the motor on the floor or wall and use a short, overhead lineshaft with three pulleys, one for the motor belt, one for driving the pump and the other for driving the machine shop. (2) Mount the motor on the ceiling and connect it directly to a short lineshaft with two pulleys, one for the pump and one for the machine shop. (3) Mount the motor on the floor and drive the pump directly through a speed reducer. In this case I would use between the motor and the speed reducer a short piece of shaft on which would be mounted a pulley driving an overhead shaft, which in turn would be belted to the machine shop lineshaft. Will someone please tell me which of these combinations would be best from the standpoints of cost, maintenance and operating advantages? Do you know of a better type of drive than I have outlined?
Chicago, Ill. O. H. E.

Answers Received To Questions Asked

Where Does a Lineshaft Usually Break?—Recently a 4 3/16-in. shaft broke underneath the hub of a 36-in. pulley sheave carrying eight 1 1/4-in. ropes. Several millwrights have told me that a lineshaft always breaks in the hub of the pulley, but none of them could tell me why. I should like to know if other readers have had a similar experience and if they can give any explanation of why the shaft breaks in this location. I am anxious to avoid a repetition of this trouble, if possible.
Chicago, Ill. R. C. M.

Answering R. C. M.'s question, a lineshaft, like a chain, usually breaks at its weakest link. In this case the weak spot of the shaft is in the hub of the sheave or pulley due to having the bearings too far away from the sheave. With a heavy pull at this point the continual bending of the shaft eventually breaks it.
Master Mechanic, H. H. LANGBEHN.
Port Vegetable Oil Mills,
Portland, Ore.

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In reply to R. C. M. I would say that the greatest stress always comes at the hub of a pulley on account of the pull on the shaft. Also, the shaft always has a certain amount of vibration the continuance of which will cause the shaft to crystallize and break next to the hub of the pulley, as the hub is solid and will not give. There is a certain amount of give in the bearings and to eliminate further breaking of the shaft place the bearings as close to the hub of the pulley as practicable.
Chief Electrician, E. N. DILLARD.
Booth Kelly Co.,
Springfield, Ore.

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Replying to R. C. M., a shaft may break underneath the hub for the following reasons:

(1) The torsion or twist due to the load is concentrated at that point, or in other words it is subjected at that point to probably the greatest stress. It may, therefore, fail due to a gradual breaking down at that point.

(2) If the shaft has a keyway at the point where the pulley is attached, its section is reduced, so that if it is not correctly designed for the load carried, it may fail from this cause. (3) The question does not state how the

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pulley was mounted or attached to the shaft. If the shaft has a section turned off for a pulley with a fillet on one or both sides of the pulley section, the turning of the shoulder may result in a weak section which will eventually break.

On the other hand, shafts have been broken due to crystallization at a hanger due to pounding when hangers were out of line. Careful design and installation will eliminate most shaft troubles.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

Referring to R. C. M.'s inquiry, an explanation in simple terms would be that a shaft breaks in the loaded pulley, first, because the pull of the belt or ropes produces the greatest bending there, just as a man breaks a stick over his knee; second, because at that point there is usually a keyway to weaken the shaft and provide a sharp corner from which to start a crack; and, third, because, with the turning of the shaft there is with every revolution a back-and-forth bending action which eventually, if the pull is at all heavy, causes crystallization, or fatigue of the metal, which may eventually result in a break.

One might think that the pulley hub has sufficient reinforcing effect to stiffen the shaft and cause the break to come at one side, and occasionally it does. However, in practically all cases where split pulleys are used there is give enough in the bolts to allow the shaft to deflect to some extent inside the pulley hub, and most solid pulley hubs have sufficient clearance for slipping on the pulley while the metal in the hub is light enough and compressible enough in the bore to permit considerable bending.

We have had several breakages of this sort, but as the belts were not unduly tight and the shafts were of ample size for the horsepower carried at the speed we were inclined to suspect that the material of the shafts was not adapted to cold rolling and that a certain amount of crystallization or an incipient flaw existed when the shaft was installed and gradually developed in operation. On replacing the defective shafting with shafting from another source, no such trouble has recurred. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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Referring to R. C. M.'s question, a lineshaft usually breaks where the stresses on it become greater than its strength to resist them. In the case R. C. M. cites, the shaft is too small in diameter or the bearings supporting it on each side of the pulley are too far away. The center line of the pulley is the point of greatest bending moment and the stresses set up in it at this point are due to deflection rather than torsion. These stresses, which are apparently above the safe limit, are alternately tensile and compressive in each revolution of the shaft, so that in a short time the strength of the metal is reduced.

In order to avoid a repetition of your trouble, move the present bearings or provide bearings closer to the pulley. Another alternative is to bore out the hub of the pulley and install a larger shaft at the place where it passes through the hub. The larger shaft may be turned down for the bearings since they have not given you trouble. The amount of increase necessary in the shaft diameter will depend on the distance between bearing centers and the outside diameter of the pulley hub, which information is not given in the inquiry. W. A. PLANT.
Power House Foreman,
Mattagami Pulp & Paper Co.
Smooth Rock Falls, Ont., Can.

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R. C. M. asks if readers can explain why shafting breaks at the hubs of pulleys. He describes the breakage of a 4 7/8-in. shaft under the hub of a 36-in. sheave carrying eight 1½-in. ropes which, by the way, is a rather small sheave for that size rope.

It would be surprising if a shaft broke anywhere but at the pulley; this is the point of maximum bending moment, and is usually weakened by a keyway. At a speed of 200 r.p.m. a 4 7/8-in. shaft is capable of transmitting more than 200 hp., and the eight 1¼-in. ropes about 90 hp.; so it seems that the shaft in this case is amply strong for the service. It is, therefore, hard to say just what caused the break, assuming, of course, that the distance between bearings is not so great as to cause an abnormal bending stress. Whether the shaft failed by fatigue or because of defective material, can best be answered by R. C. M. as he has the shaft, and probably its history, available for investigation.
Los Angeles, Cal. C. O. SANDSTROM.

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Referring to the problem by R. C. M., the shaft broke in the hub of a pulley which was either pressed on or was clamped tightly on the shaft. Probably the most common reason for breaking at this point is the vibration of the shaft. The rate of vibration changes at the heavy wheel hub, which cannot vibrate at the same speed or direction as the shaft. This causes crystallization in the steel and in time it breaks.

Another cause is the stress set up by the torque on the lineshaft. The shaft when under load twists to some extent but an enlarged place or hub pressed on acts to stop the twisting at that point. This may cause considerable working of the steel at that point, and the result is the same as stated above.

The breaking of shafts is very noticeable where wheels are pressed on, as for instance car wheels. Almost invariably a car axle breaks close to the wheel, and on electric cars the axle, which carries the motor and gear, gives the most trouble. For this reason, these axles are usually enlarged for the gear and wheel fits in order to help overcome the trouble.

Breaking from this cause starts on the outside and works to the center, but not in a circle, as the harder parts of the axle will break down first.
Longview, Wash. C. L. HARTMAN.

What Is Wrong with the Method of Rewinding This Armature?—I have a Willey electric drill, serial No. 20063, 110 volts, a. c., 6 amp., Type 4 U. C. 2, which is manufactured by the James Clark, Jr., Electric Co., Louisville, Ky. The armature has 17 slots and 32 bars, and is wound with No. 23 cotton-covered enameled wire, using 13 turns per section, with a coil span of 1 to 8, and the leads checking straight out. The armature is hand-wound, left-handed, with the commutator to the right. The only change was that I rewound it right-handed instead of left-handed. I expected that the motor would reverse its direction, which it did. When the drill was connected to the line, both brushes sparked badly, which convinced me that they were off their neutral position. I moved the brush holder to different positions around the commutator, but could not find the neutral point. I took the brush holder head off and checked the leads, which were O. K. Finally the armature was stripped and rewound the same way as before except that I changed the span of the coil from 1 to 8 to 1 to 9. Without moving the brush holders from the position set at the factory, the drill operated perfectly. Why would this armature not operate with the coil span 1 to 8 and wound right-handed? Would winding this armature right-handed instead of left-handed have any effect besides reversing rotation?
Richmond, Va. H. F. S.

In reply to H. F. S.'s question, when the direction of rotation of a universal motor with a compensated winding is reversed, the polarity of the compensating winding should at the same time also be reversed.

The polarity of the compensating winding should be the same as the main field adjacent to it against the direction of rotation.

The above explains the reason for not being able to find a brush position that would give sparkless operation, with the reversed winding.
Wilkinsburg, Pa. A. C. ROE.

* * * *

In answering the question by H. F. S., I would say that all of our small armatures are machine-wound. It is much easier and better for us, with our equipment, to wind the armatures with the commutator on the right side, the wire being put on left-handed or counter-clockwise. If an armature were rewound right-handed or clockwise and connected up the same as originally, the only change, if everything else about the motor is the same as it was originally, would be to reverse the direction of rotation. To counteract this effect and make the motor operate in the same direction as before it is only necessary to reverse the brush leads or, if the motor is so arranged, the whole brush mechanism could be rocked half-way around and the motor would reverse. According to the information received, this was done and the motor sparked in any position. Such being the case, we are led to believe that there was something wrong somewhere, aside from the manner in which this armature was rewound.

Stripping the armature and rewinding in slots 1 and 9 instead of 1 and 8, and winding right-handed instead of left-handed, brings the leads out in the same position as if the armature had been wound left-handed, 1-and-8. Since the number of slots in the armature is 17, winding it 1-and-8 brings the leads one slot this side of 17, as 2 times 8=16; a span of 1-and-9 brings it one slot on the other side of 17, as 2 times 9=18. Winding it right-handed

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reverses this condition and winding it 1-and-9 reverses it again, which brings it back to the original condition.

The writer is assuming that when the armature was stripped and wound 1-and-9 instead of 1-and-8, it was wound right-handed, the same as when he wound it in the beginning.

President J. A. CLARK, JR.
James Clark Jr. Electric Co.,
Louisville, Ky.

* * * *

There is nothing wrong with the method of winding the armature, as explained in the question asked by H. F. S. Changing from a left-hand throw to a right-hand throw would give a reverse direction of rotation, as well as a reverse direction of current through the armature. On this type of motor a compensated winding is used to produce a magnetic flux which will oppose the magnetic flux produced by the alternating current in the armature. If the flux produced by the alternating current in the armature is not neutralized, it will induce a current in the coils under commutation, causing sparking.

In this case the flux produced by the alternating current in the armature is reversed, due to changing the winding from a left-hand to a right-hand throw. Therefore, the flux produced by the alternating current in the armature being reversed will add to the flux produced by the compensated winding. Had the compensating winding been reversed, the motor would have operated without sparking.

When the armature was rewound, the change to a span of 1-to-9 instead of a span of 1-to-8 did not affect the commutation of the motor so long as the coil had a left-hand throw. This permitted the flux produced by the compensating winding to neutralize the flux produced in the armature.

J. M. ZIMMERMANN.
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

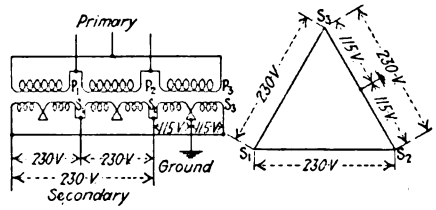
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How Should a Delta-Connected Transformer Bank be Grounded?—I should like to know some of the standard or practical methods of grounding a delta-delta connected bank of transformers. We have a transformer bank consisting of three single-phase, 13,200/440-volt transformers, which are delta connected on both the high- and low-tension sides. Now I get a reading of about 100 volts from each 440-volt bus to ground. Consequently, I am planning to ground the low-tension side of the transformer bank. Can some reader tell me to what part of the low-tension delta I should connect my ground or what reactors or other devices I must use to obtain my ground connection?

Omaha, Neb. G. C. B.

The accompanying diagram will show G. C. B. how a delta-connected bank of transformers may be grounded. As may be seen, the middle point of any one transformer in the delta-connected bank may be permanently connected to ground to form the ground connection.

Before grounding the transformer as shown in the diagram, all of the circuits that originate from this bank of transformers should be tested for any accidental grounds that may already exist on them. It is best to eliminate any grounds that may be found.



Here is one method of grounding a delta-connected transformer bank.

In case it is necessary to operate a delta-connected transformer bank in open delta, the grounded transformer should not be the one that is cut out. If it is necessary to cut out the grounded transformer, the ground connection should be moved to one of the other transformers.

When a secondary circuit is permanently grounded as is shown in the accompanying diagram, all meters on the secondary side should be checked and the current coil or coils on the meters transferred to the ungrounded lines. This is important and care must be exercised to see that it is done.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Oklahoma.

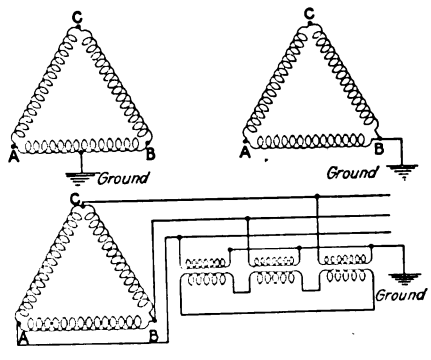
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In reply to G. C. B.'s question in a recent issue, the delta-delta connected transformer bank may be grounded on the low-voltage side in a number of ways. The accompanying illustration shows the low-voltage delta and three methods of grounding it that are in common use.

The upper left-hand sketch shows a method of grounding at the middle point of one of the windings. Although this method is often used, it has the objection that while the voltage from lines *B* and *C* is only one-half of 440, or 220 volts, the voltage from line *A* to ground is 381 volts.

The upper right-hand diagram shows a method wherein one of the lines is grounded. This method gives full line voltage to ground from lines *A* and *C*.

In the lower diagram is shown a method of grounding in which three small transformers are star-connected to the three lines, *A*, *B*, and *C*, with the grounded neutral on the 440-volt side and connected in closed delta on the other side. With this method it is not absolutely necessary that the star-connected side be a 381-volt winding, as the same effect will be obtained if a higher voltage winding is used.



Three methods of grounding a delta-connected transformer bank.

Of these, the method shown in the bottom diagram is to be preferred. The second best connection is shown at the upper left.

This method is to be preferred if the expense of the grounding transformers can be justified, since it gives a balanced voltage to ground on all lines.

The method shown at the upper left-hand corner of the diagram is the second best method of grounding, but requires a tap at the middle point of one of the windings. The method shown at the upper right-hand corner of the diagram, should not be used unless either or both of the others are out of the question, for it gives line voltage to ground for two of the lines, *A* and *C*, and a ground on either line would probably give more trouble than would be encountered with either of the other two methods.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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In reply to the question asked by G. C. B., one standard method of grounding is to connect the middle point of one of the transformers to ground, as shown in Fig. 1. If there are no middle taps on the transformers, then one corner of the delta, that is, one line wire, must be grounded.

When grounding a transformer bank,

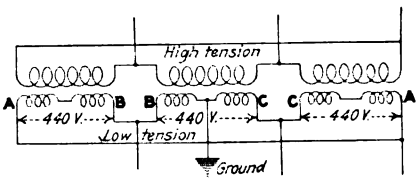


Fig. 1—The middle tap of one transformer in a delta-connected bank may be used as the grounding point.

as shown in Fig. 1, it should be noted that the voltage from two of the line wires to ground will be 220 volts and from the remaining line wire to ground will be 381 volts. This is clearly illustrated in the left-hand diagram shown in Fig. 2. In this diagram the middle tap of transformer *BC* is grounded. Hence the potential from point *B* or *C* to ground will be 220 volts, while the potential of *A* will be 381 volts above ground potential. The right-hand diagram in Fig. 2 illustrates the conditions that exist when the delta is not grounded. In this case the stress to ground is the same from each line wire, being 254 volts. Inasmuch as the insulation of one wire is under a 381-volt strain to ground, more motor insulation failures are likely to occur with a grounded secondary installation of this kind.

If other banks of transformers are operated in parallel with the grounded bank, care must be taken to see that all banks are grounded in the same place; that is, if transformer *BC* is grounded in the first installation, all succeeding installations must likewise have the transformer *BC* grounded. This is to prevent short-circuiting part of a transformer winding.

One advantage of the grounded secondary system is that it prevents trouble from capacity effects. A person coming in contact with a wire of an ungrounded system may receive a

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shock, due to the capacity effect between the high- and low-tension windings of the transformer. The higher the primary voltage of the transformer

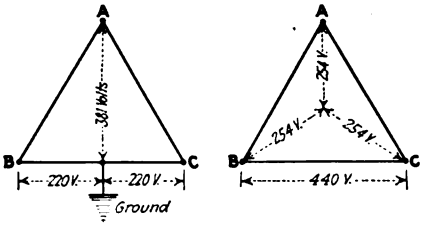


Fig. 2—Grounding of the middle point of a transformer gives an unequal voltage stress to ground on the three line wires.

As shown at the left, lines *B* and *C* have a potential to ground of 220 volts, while line *A* has a potential of 381 volts to ground. Voltage stresses to ground on an ungrounded delta-connected bank are equal, as is shown in diagram at right.

and the larger the system, the greater will be the condenser or capacity effect.

Installation of reactors or other devices in the ground circuit is not to be recommended as this may interfere with the correct operation of protective devices.

L. P. STAUBITZ.
Chief Electrician,
LaClede Steel Co.,
Alton, Ill.

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What Causes These Brushes to Chatter?—I have a three-phase, 440-volt, 75-hp., slip-ring motor which is giving trouble from chattering of the brushes. Everything that I know of has been tried to prevent this, but without success. The brushes will stop chattering immediately after the slip rings are sanded slightly while the machine is in operation, but after several hours they begin to chatter again. I shall apreciate it very much if some of the readers of INDUSTRIAL ENGINEER will tell me how I can overcome this trouble.

Los Angeles, Calif. F. P. B.

Replying to F. P. B., try changing the angle of the brushes. This is often an important factor.

I recall an engine-driven generator I had that would develop brush trouble once in a while, and I found no positive relief for this other than to take the rings off, turn them down and polish at high speed. This would end the trouble until a new brush was needed ,and particular care had to be exercised to rid the ring of the slightest sparking or it would immediately develop into serious arcing. I found temporary relief through the use of a little vaseline on this particular machine; this is one way of preventing chatter, and is sometimes sufficient.

Particular care must be exercised in fitting brushes to such temperamental rings; I have found it advantageous to smooth off both the toe and heel of such brushes.

Having brushholders too far removed from the ring is often the cause of chattering and is an inducement in all cases. Brushes that are too loose in their holders, with too little tension, have a tendency to chatter and brushes that are too narrow to carry the current or have a tendency to run off the ring may begin with a sparking that will develop into chattering with bad arcing.

I have found sanding to be of little value in stopping a brush from chattering, and the effect lasts about as long as an application of vaseline. Where vaseline has a noticeable value a change of brushes will generally correct the trouble.

Without making recommendations as to its use or its value, I have corrected slight chattering with the use of a soft lead pencil while the machine was in operation. It is effective for obvious reasons, but is not recommended as a "cure-all."

EDWARD JAMES.
Newark, N. J.

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Answering F. P. B., it is assumed that the machine did at one time operate satisfactorily. Chattering of the brushes may be due to several causes, such as worn bearings, worn shaft, bent shaft, variable load with more or less shock, very heavy starting load and so on. Anything that will cause a movement between the slip rings and the brushes radially will have to be eliminated. See that the brush holder is quick acting; that is, that the brushes can follow any slight movement of the slip rings. Also, make sure that the slip rings are tight to the shaft, that the rings run true, and that the brushes move freely in the holders.

The springs may have taken a set and will need replacement. If correcting according to the above suggestions does not eliminate the trouble, it may be that the slip rings have some spots that are softer than others and wear faster. The brushes should be able to carry their load easily and should be of a low resistance with sufficient lubricating material in them to prevent cutting.

C. N. SHAFER.
Supt. Service Division,
The Lincoln Electric Co.
Cleveland, Ohio.

* * * *

In a recent issue, F. B. P., mentions the trouble he is having with brushes chattering. The rings have evidently become worn out of round due to natural wear, or because the motor bearings are slightly worn. Sometimes an armature shaft becomes sprung, causing the brushes to vibrate or chatter badly.

We have had numerous cases of this kind and to remedy the trouble, generally take the rotor out and turn the rings down in the lathe.

However, some motors cannot be shut down long enough for this purpose; so we use a home-made tool for truing up the rings. This tool was made by grinding the end of old file square and making the edge as sharp as possible. When truing up the rings the motor is run up to full speed and the sharp cutting edge of the file held firmly against the rings (one at a time, of course) until they are reasonably true. It is surprising how true the rings can be made in this way. We have in this way stopped chattering that had continued for 18 months or more. When the rotors were at length taken out, it was generally for some other reason.

It is advisable to give the rings a good sanding down with sandpaper after they have been trued with the file.

GEORGE D. RINGNESS.
Peoria, Ill.

In reply to the question by F. P. B. I think that the chattering is caused by the collector rings and brush surfaces being unevenly hard; possibly the rings have small, flat spots that are not easily detected.

I would recommend that the rings be turned or ground true and smooth. Then use a medium soft brush (with shunts attached) well fitted to the holder. The springs should press firmly against the brushes.

Often we find that the shunts will become loose on the brushes, thus allowing the springs to carry most of the current. This heats and weakens the springs and starts trouble.

WILLIAM J. MILDON.
Supt. Power and Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

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Referring to F. P. B.'s question, I believe that your brushes are too hard for slip-ring service and the reason they stop chattering immediately after sanding the rings is that the sanding removes the roughness that the brushes have cut into the rings.

Of course, there are other causes of chattering: the usual cause is that the brush is too small for the box or holder. Vibration will cause chattering, as will also eccentric or pitted rings. However, I do not believe that a slight sanding would stop or prevent chattering if it were caused by any condition other than excessive hardness of the brushes which will make the rings rough, as mentioned above, and thus cause the brushes to chatter.

I presume that the rings are brass or bronze and I would recommend using grade No. 414 or No. 539 brushes, manufactured by the National Carbon Company.

GRADY H. EMERSON.
Asst. Chief Electrician,
Alabama Fuel & Iron Co.,
Acmar, Ala.

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Mounting Motors on Ceiling—In order to get more free floor space we are planning on mounting the motors on the ceiling, above the machines and lineshafts which they drive. I should like to have the experiences of other readers on the following points: (1) The best method of attaching motors to concrete ceilings. (2) What is the best and simplest method of raising and holding motors up until they can be attached? (3) Is there likely to be any more trouble with motors so mounted, than when they are placed on the floor?

St. Louis, Mo. E. H. G.

In reply to the question by E. H. G., I wish to suggest the following: Drill four holes in the ceiling to correspond with those on your motor. Countersink the holes on the floor above to accommodate the heads of the bolts, and a large washer. From the floor above, drop a steel cable through two of the diagonally opposite holes drilled in the floor. Place the motor on a platform to raise it off the floor about 4 ft. This is done to lessen the distance through which the motor will have to be raised, and thus make it possible for the hoist to lift it up to the ceiling. The motor should be placed with the base turned up. Insert one end of the cable in one of the holes in the motor base and the other in the hole diagonally opposite, and clamp the ends fast. Attach a hoist on the floor above, hook the cable

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to it and pull the motor up flush with the ceiling. Now, drop two bolts of the proper length and size in the two vacant holes in the motor base and draw them tight. These bolts will hold the motor until the cable can be removed and replaced by the other bolts.

Make sure that the oil wells are turned to the proper position and you will not have any trouble with motors so mounted.

Jersey City, N. J. B. DOWICK.

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With reference to the question asked by E. H. G., you will not have any more trouble with motors mounted on the ceiling than when placed on the floor, providing that you give them as much attention on the ceiling as you did on the floor. On the ceiling they are up out of the way, and not so easy to get to.

Motors may be bolted to a frame or base made of 4-in. by 6-in. timbers. If necessary these timbers may be bolted to the ceiling by bolts through the floor above, or through the roof.

Almost all new buildings now have cast-iron inserts in the ceiling for the purpose of bolting timbers to them for mounting motors and other equipment. Do not try to use anchors of any kind to hold motors on the ceiling; there is always danger of them coming loose and causing trouble.

Run bolts all the way through the ceiling to the next floor or roof. My motors are mounted this way and I have not had any trouble with any of them coming loose. On the other hand, I have had plenty of trouble with anchors.

If the ceiling is wood it will be all right to use lagscrews for supporting the motor. As to the equipment for raising the motors, I would suggest that you get a Revolvator, made by The Revolvator Co., Jersey City, N. J. This will put up and take down all the motors you can handle.

Indianapolis, Ind. H. F. FOX.

* * * *

Answering E. H. G.'s question, in modern factory buildings it is now customary to have mushroom anchors set in on definite center distances at the time the building is erected, so that you can readily fasten up cross-members to which you can attach your motors, or rails or motor supports.

Motors can also be fastened up by cutting holes through the ceiling. Holes in the floors above should be countersunk deep enough to sink the heads of the bolts flush with the surface and when the motor is in place fill around the bolt heads with cement grout. If the motors are on the ceiling under the roof, you should provide bosses on the roof and cover these with caps to keep out water. These raised bosses should, of course, be flashed to the roofing so that they will be water- and weatherproof.

Motors can be raised by the aid of portable stock tiering or hoisting elevators, or by putting the ends of a wire cable down through two diagonal holes which have been cut for supporting the motor or its mounting and then through the corresponding holes in the motor or motor supports and placing clamps on the cable ends so they will not slide or let the motor drop down.

If the motor has rails it should be bolted to, and lifted by, the rails. Be sure that you have enough hoisting range so that you can lift your motor all the way. If not, provide blocking so that you can hold your motor and get another lift on it by taking the slack out of the cable. When the motor is pulled up, place the nuts on the two free bolts and then remove the cables and drop the last two bolts in place and tighten them up. Be sure to provide locknuts on all holding bolts so that if they should tend to vibrate loose, the motor will not drop.

With the same maintenance you should have no more trouble with motors on the ceiling than on the floor. However, it will as a rule be warmer next to the ceiling, so that the same load will cause a somewhat higher operating temperature. C. N. SHAFER.

Supt. Service Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

* * * *

My advice to E. H. G., about placing his motors on the ceiling, is: Don't do it. If you desire to take them off the floor, which is commendable in utilizing floor space, do not go to the other extreme and place them against the ceiling; or at least before the change is made, visit some shop in which they are so located and try to look into the motors. Make a casual examination of their condition and at the same time try to ascertain whether you could give the motors better maintenance than the electrician who has charge of it.

To emphasize this, I might add that I recently completed an inspection of several such installations and in some cases it was next to impossible to make brush changes, let alone try to have 100 per cent maintenance, with the result that good motors are being sacrificed, with enough competent men available to keep them in good condition, if they could only reach them so as to make a worthwhile inspection of their condition.

I do not mean to imply that motors should not be taken off the floor, but do not put them on the ceiling. Put them on a platform that is far enough below the ceiling to permit the motors to receive as good maintenance as they could get on the floor. They will not receive this unless a competent chief checks up on his maintenance crew often, for this type of installation was the example for the saying, "Out of sight, out of mind."

If motors are mounted on a platform, a tackle can be used for raising and lowering them, and no more trouble will be experienced with this method of installation than would be encountered with floor mounting, providing that a rigid platform is used.

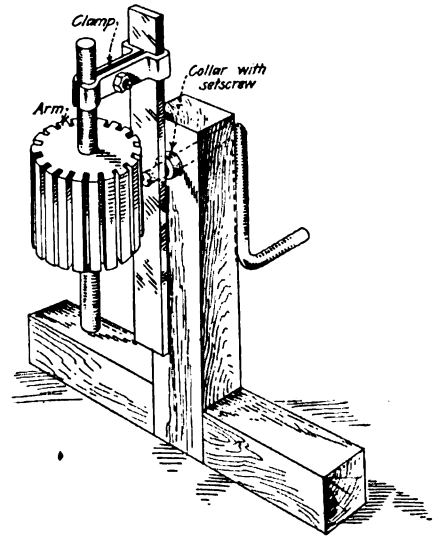
Electricians sometimes overlook overhead protection, as well as ventilation, for this type of mounting. Remember that near the ceiling the temperature is higher, and dirt from the floor above may give trouble.

Newark, N. J. EDWARD JAMES.

Simple Device for Winding Small Armatures—I should like to know if any of our readers can tell me how to construct a simple machine that can be made in the shop and used for rewinding small armatures of the fan and vacuum cleaner types. I should also like to know what other equipment is necessary for the rapid handling of this kind of work. Winding these armatures by hand is too tiresome and slow, and we do not have enough of this work to warrant the purchase of an expensive winding machine.

Brooklyn, N. Y. G. A. L.

G. A. L. can make a simple machine for winding small armatures by following the ideas set forth in the accompanying diagram. Take two maple blocks 2 in. by 2 in. by 12 in., notch out the center of one and the end of the other, and place them together to form a T. This is the support or standard for the device. About 1½ in. from the top of the vertical piece, insert a bronze bushing to take a ½-in. shaft.



An easily-made device that will save much time when winding small armatures.

The crank is made from ½-in. round iron, bent as shown in the diagram, and threaded on one end for a distance of ½ in. A piece of steel ¼ in by 1¼ in. by 12 in. is drilled and tapped at the center for the threaded end of the crank.

The clamps for holding the armature to this steel strip are made from strap iron, bent as shown in the accompanying diagram. E. H. WINKLER.

Chief Electrician,
Allen B. Wrisley Co.,
Chicago, Ill.

* * * *

In reply to the question asked by G. A. L., the diagram shows the construction of a simple armature winding machine that I made up and found to work very satisfactorily. This machine can be constructed in the shop at a very small cost and will effect a considerable saving in the time required to wind small armatures.

As may be seen, the armature is clamped by two holders *m m*. The screws on these two holders do double duty; first they tighten the clamp on the armature and, second, they hold the two brass pieces *d* which direct the

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wire into the slots being wound. The wire is fed through the pulley *c* and thence down the guide *d* into the slot. The strip *f* is made adjustable so that the pulley can be moved for different sizes of armatures.

The shaft clamps *m* are fastened to strip *b*, as is shown in the diagram, so as to permit adjusting the device for different sizes of armatures.

The strip *b* is fastened to the shaft *t* which is revolved by means of a crank. The shaft *t* is threaded with about 220 threads between *p* and *q*. Resting on the threaded shaft is the lever *a*, the underside of which is threaded somewhat like a split nut, so that as the threaded shaft *t* is revolved the lever *a* is moved from left to right.

Having taken the commutator and fan off the shaft, (as only armatures in this shape can be wound on the machine) the armature is clamped in the holders *m m*. The lever *a* is put in such a position that the number of threads on the shaft to the right of it is equal to the number of turns it is desired to have in a coil. As the coil is wound the lever moves to the right and when it reaches the end of the shaft, indicates that the coil is completed. A loop is then made, the armature turned so as to bring new slots into position, the lever *a* is placed in the former position, and the next coil is wound.

It will be found advisable to have the crank connected to the shaft *t* by means of a few gears, rather than connected directly. This arrangement will speed up the work.

New York, N. Y. L. KONSTAN.

* * * *

What Kind of Wire Should Be Used Here?—We are having considerable trouble from grounds and shorts due to the insulation failing on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery, and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinary rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?

Tulsa, Okla. L. A. N.

If the pyrometer lead wires mentioned in L. A. N.'s question are of copper, I would suggest using No. 14 duplex lead-covered cable which is a two-conductor No. 14 copper wire; each wire is rubber-covered and braided and there is a serving of braid over both, which are then protected by a lead sheath. This wire will work under water and will stand a conduit temperature of about 375 deg. F.

If the conduits have a 4-in. space between them and furnace walls, hot oil lines, steam lines, etc., their temperature will usually be found to be below 300 deg. F.

Some pyrometers and thermocouples require special compensating lead wires (wires made of the same material as the thermocouples), so that the cold junction can be taken care of by a compensating coil in the indicator or the recorder. These wires can be purchased from the maker of the pyrometer, in lead-covered duplex form. This type of wire has never given us any trouble.

Chief Electrician CHAS. L. BROWNE.
Producers and Refiners Corporation,
Tulsa, Okla.

* * * *

L. A. N. will have no further trouble with his wires in conduit in very hot applications if he uses all asbestos insulation on his conductors. For the past few years I have used solid and stranded conductors with asbestos insulation, such as Deltabeston stove wire, with great success for pyrometer and other circuits around open-hearth furnaces and in other very hot places.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In reply to the question asked by L. A. N., I would say that we have had similar trouble with wires in conduit on pyrometer work. The only remedy for this trouble that we have found so far is to do away with the conduit entirely and run flame-proof compensating leads in open construction from the thermocouples to the instruments.

The method of construction sometimes used has been to stretch small messenger wires well above the furnaces, the thermocouple leads being taken directly up to the messenger and carried along it in loops of flame-proof wire over to the instruments. This construction is reasonably good in appearance and gives very little trouble.

Electrical Dept., W. W. LANKTON.
Detroit Copper & Brass Rolling Mills,
Detroit, Mich.

* * * *

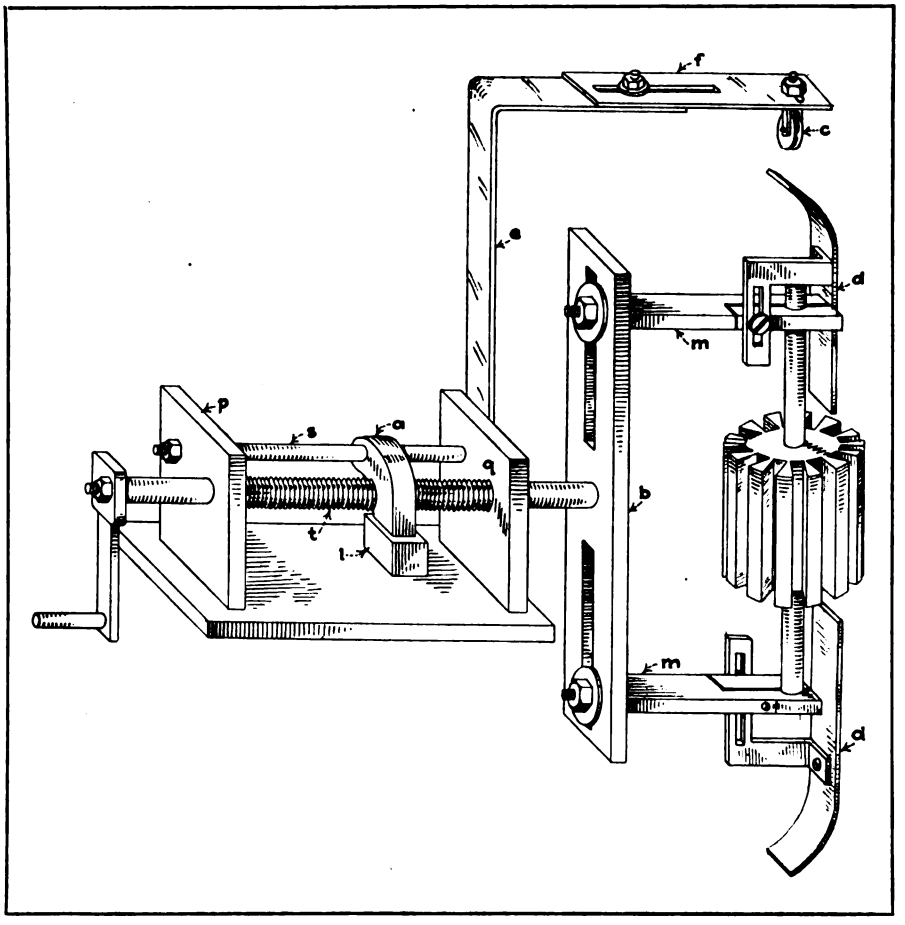
The trouble experienced by L. A. N. is due to air circulation in the conduit and can be eliminated by stopping the circulation of air through it.

When rubber-covered wire is run to the thermocouple, the heat of the still soon causes deterioration of the rubber insulation. When flame-proof wire is used, the insulation soon absorbs the condensed moisture, thereby causing a short.

The best method of overcoming this is to use a good grade of asbestos wire from the thermocouple to the point where the conduit starts to cool. This point is generally where the pipe runs through the wall of the room. From the cooling point to the pyrometer, use rubber-covered wire. At the junction box where the two types of wire are spliced, plug both ends of the conduit and fill the box with pitch or any insulating compound so as to prevent the warm air from entering the cool portion of the conduit.

Also, drill a small hole through the underside of the conduit at all low points to allow any condensation that may collect, to run off. Sometimes it is advisable to plug the conduit in two or more places where alternate sections are heated or cooled.

Here is a device that will speed up the winding of small armatures.



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The above method is one that I have used with success in a chemical plant. I feel sure that it will answer L. A. N.'s purpose if the box is properly inspected once in a while, replacing any compound that may have run off.

Elizabeth, N. J. W. H. FREDRICKSON.

* * * *

Answering L. A. N., the trouble referred to is apparently due to condensation in the conduits, judging from the information given. The solution most readily applied would be to replace the rubber-insulated, braid-covered wire with rubber-insulated, lead-covered conductor. This change might require new conduit, although, if the conductor is not subject to, or in danger of, mechanical abrasion it might be run exposed.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

I think the first thing L. A. N. should do is to try and eliminate condensation in his conduit installation.

My experience has been with Brown Instrument Co.'s equipment, using type MA 30-in. base metal thermocouples on recording and indicating pyrometers. These are used for temperature measurements in our malleable iron annealing ovens.

We formerly used No. 12 rubber-covered extension leads but had trouble with grounds and shorts due to the roasting of the insulation. Asbestos-covered wire was tried with a little better results but after being installed for a while the insulation baked brittle and would not stand any alterations. Finally, we installed Type A extension leads made exclusively by the Brown Instrument Co., Philadelphia, Pa., to be used with their type MA thermocouples. These leads are composed of a stranded copper and a nickel-aluminum conductor very well insulated and woven together in duplex form. This company also manufactures several other grades of extension wire to be used with their several grades of thermocouples.

Since this installation was put in we have had very satisfactory results from our pyrometers. W. A. BERGSMA.
Chicago Malleable Castings Co.,
Chicago, Ill.

* * * *

Referring to L. A. N.'s question, I presume that a metallic circuit system is used in your pyrometer wiring; that is, there is no common return. This being the case I would recommend using duplex, lead-covered, No. 10 wire in about ¾-in. conduit. At the beginning and at the end of the conduit I would pour some pothead compound in the condulets. This will seal the end of the lead so that no moisture can get to the wire in the conduit. Peel off the lead inside the condulet for about ¾ in. below the end of the pipe. This can be done before the condulet is screwed on. The condulet should also be drilled and tapped for a ⅜-in. pipe plug at what will be its highest point when installed. Waste or oakum should be packed tightly around the lead an inch or so in the conduit. The condulet cover should then be put on and waste packed around the wires so that the hot compound will not flow out and be lost.

Melt the compound and pour it in at the drilled hole; fill to overflowing, as the compound shrinks when it cools. While it is still hot, screw the plug in the hole. If the heat is great enough to keep the compound molten or drippy, a fiber cover can be substituted for the porcelain and the holes for the wire drilled to a tight fit. It matters not whether the compound is molten or cool so long as it covers the end of the cable. The General Electric Company makes a compound which has a very high melting point and I believe that it would suit your case. Of course, the conduit should drain to one point, in this instance, and some means of eliminating the moisture should be provided.

The covering of lead is not very thick and it must be carefully handled if it is to give good results. In pulling in lead cable I usually feed the cable and have a can of cup grease handy, which I use so that the lead will not be scraped, and to lessen the power required for pulling.

GRADY H. EMERSON.
Asst. Chief Electrician.
Alabama Fuel & Iron Co.,
Acmar, Ala.

* * * *

I have had trouble similar to that experienced by L. A. N. due to steam getting in conduit lines. If L. A. N. will use asbestos-covered wire, give his conduit line a slight incline and have all fittings vapor-tight, he will have no further trouble. A small drain hole should be put at the lowest point in the conduit run so as to drain off condensed moisture.

Chief Electrician, E. N. DILLARD.
Booth Kelly Co.,
Springfield, Ore.

* * * *

In answer to L. A. N., it is evident that one cannot use a weather-proof wire and subject it to extreme heat, or use slow-burning wire in damp places. I doubt whether you can get any wire to suit both purposes at the same time.

I would suggest, first, that you arrange the conduit line so that it will drain off the condensation; try installing several outlet boxes with blank covers at regular intervals along the line. I would say about five boxes in every 300 ft. It may be necessary to drill a few extra holes in the boxes, ⅛-in. holes would be plenty large enough.

Pull in weatherproof wire, or even lead-covered cable, if necessary, up to the point where the heat becomes excessive. Then pull in slow-burning wire from furnaces to nearest junction box, and make splices to the weather-proof wire.

Another point; do not crowd the wires in the pipe. Leave plenty of room. There should not be more than three No. 14 wires in a ½-in. conduit otherwise crowding will take place, which should be avoided.

Los Angeles, Calif. H. A. NIELSEN.

Method of Drilling Holes Through Plate Glass—I have to drill some holes in plate glass ¼ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.
Little Rock, Ark. M. J. J.

In replying to M. J. J., he might use a method which proved satisfactory in making some chemical laboratory equipment which was constructed entirely of glass and required the drilling of several holes.

These holes were drilled by means of a triangular file turned in a brace. Files of the required sizes were ground smooth on all three sides, care being taken not to draw the temper of the steel. The drilling was rather slow and a stream of water was kept flowing across the holes to keep the drill cool and to carry away the glass dust. If it is not possible to use a stream of water, the drill should be moistened with turpentine. D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In answer to M. J. J., I have tried many methods of drilling glass and the one I have found to be the most satisfactory for speed, accuracy and neatness is to use a piece of brass tubing, the outside diameter of which is the same size as the hole to be drilled. If the tubing is used in a hand drill with emery and oil as an abrasive, a hole can be drilled without danger of cracking the glass and only a slight pressure will be required.

A block of wood with a hole bored through it the size of the tubing should be used to center the drill properly. This block will keep the tubing in place until it starts to cut. A liberal amount of emery and oil should be used during the operation.

By using a dull hacksaw blade with emery and oil for the abrasive, glass can be easily and neatly cut when an ordinary cutter can for any reason not be used. JOHN GRIVA.
Electrician,
Hotel Statler,
Detroit, Mich.

* * * *

In answer to the question by M. J. J., he can easily drill holes through ¼-in. glass by putting a few drops of turpentine on the glass where the hole is to be bored and using a drill made from an ordinary 8-in., three-cornered file.

The tempered end of such a file should be ground on an emery wheel to a very sharp, three-sided point and the handle end supported in a drill bit stock.

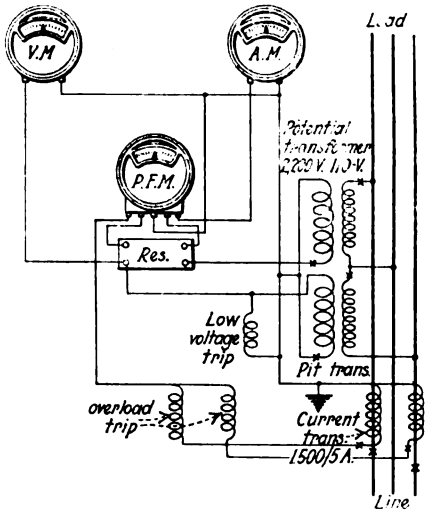
You can get smoother holes by first drilling a small hole, using a small file, and then boring it to the desired size with the large drill.

In connection with glass working I might say that almost any thickness of glass can easily be cut with an ordinary pair of tin snips, if you hold both the glass and the tin snips under water while doing the cutting. The size of the snips will depend upon the thickness of the glass that is to be cut.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Maine.

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Why Do These Meters Not Register?—We have a Weston power factor meter, Model 356, serial No. 790, and a Weston ammeter, Model 156, serial No. 43008, mounted on a switchboard manufactured by the Condit Manufacturing Co. and connected as shown in the diagram. The connections from the switchboard to the current and potential transformers were made by my



workmen. The polarity marks on the transformers are as indicated. The ammeter reads zero when power is flowing through the switchboard. The power factor meter likewise remains in the same position as when power is off the board. Is the connection scheme shown in the accompanying drawing correct? If so, what do you think is wrong and what tests should I make to locate the trouble?

Sharon, Pa. C. F. C.

Answering C. F. C., it is not possible to determine or suggest the cause of non-registration of the meters shown in the diagram. Assuming that the internal condition of each meter is satisfactory the connections seem to be conventionally correct. No details are given as to the wiring runs between the transformers and the instruments. Assuming that the voltmeter reads correctly and that the potential transformers are operating, the current transformers should be tested as follows: Short-circuit each transformer, at the secondary terminals, through an ammeter. Should readings be obtained which check approximately with the load that is being carried, it is a definite indication that there is trouble in the circuit in the portion which includes overload trips and power factor meter.

In the absence of any description of the wiring, no guess can be made as to the trouble which may exist, except that it might be either a short-circuit, if the conductors are carried in the same conduit, or a ground in the lead between the overload trip coils and the power factor meter. An ammeter connected between the common lead referred to and ground, or to the common lead from the current transformers will show whether this portion of the circuit is in operating condition. If the ammeter gives a reading of the same value as obtained in the earlier test by shorting a transformer, then the connection through the power factor meter is causing trouble.

It is barely possible that there may be an open circuit in the connections, but in the case of a current transformer this condition could not exist even under light load, as it would be shown by the heating or possibly a breakdown of the current transformers.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

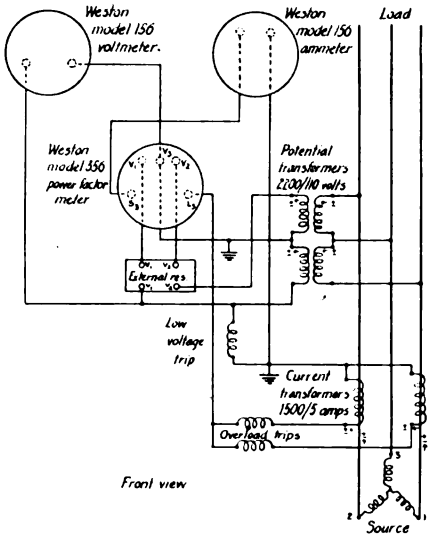
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As the back connection studs are not shown in their actual location in the diagram of connections for a Weston ammeter and power factor meter accompanying the question by C. F. C., it is assumed that the proper terminals on the back of the power factor meter have been used, and that either Weston transformers are used or the polarity marks have the same meaning as those on Weston transformers.

If these assumptions are correct, then the only error in connections is that the current connections to the power factor meter are reversed.

However, with the connections shown the ammeter should indicate correctly and the power factor meter pointer should deflect below or above the ends of the scale. Since they do not indicate at all it is evident that there is an open circuit in the current connections, possibly through using the wrong terminals on the power factor meter. A simple test for this is to short-circuit the current circuit connections to the power factor meter and if the rest of the circuit is correctly connected, the ammeter should show the proper indication.

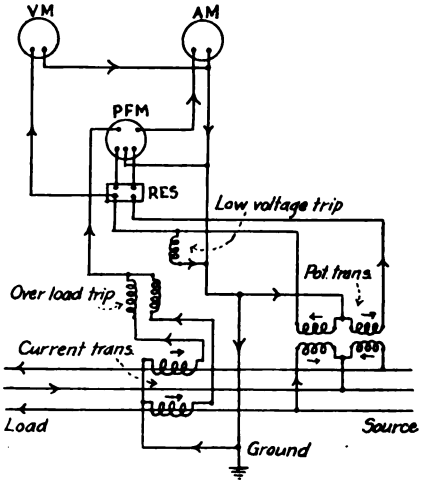
The accompanying sketch shows the proper connections for the instruments and accessory apparatus. It is assumed that two current transformers are used for connection to other instruments, such as wattmeters, as only one in the "middle line" is necessary for a power factor meter. W. N. GOODWIN, JR.
Electrical Engineering Dept.,
Weston Electrical Instrument Corp.,
Newark, N. J.



This shows the proper connections for a Weston power factor meter, using two current transformers.

* * * *

If C. F. C. will trace his current in the common return wire, he will find that he has the current traveling in at his current transformers and in the opposite direction, that is out, from his potential transformers. This will not work, as the meters will act as though connected as a shunt on one wire; that is, the current is trying to go out at both terminals at the voltmeter and



Connections for power factor meter, ammeter, voltmeter and relays.

trying to go in at both terminals at the ammeter. In fact, the current is not flowing at all. If he will connect them as shown in the accompanying diagram his meters will all register. Should the power factor meter read lead instead of lag, he can interchange two potential transformer lead wires, and if the pointer goes off the scale in the lead direction he should change both the potential lead wires and also the current wires.

He should always connect his potential transformer behind his current transformer, as shown in the diagram. when connecting switchboard instruments so that the ammeter and wattmeter will not register the current used by the potential transformer, as this load should never be registered on the meters. WILLIAM P. AMANNS.
Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.

* * * *

In answer to C. F. C. as to why his meters will not register, I would suggest that he reconnect his current transformers using one current transformer for the ammeter and one overload coil and the other current transformer for the current element of the power factor meter and the other overload coil.

Longview, Wash. B. W. HAMILTON.

* * * *

The diagram which accompanies the question asked by C. F. C., is apparently correct. The connections to the power factor meter may be checked by taking a piece of wire and short-circuiting the current terminals of the instrument. The pointer should move toward lag. If it moves toward lead the potential connections should be reversed on the line side of the power factor meter resistor. I suggest that C. F. C. test the circuit from the current transformers for an open circuit.

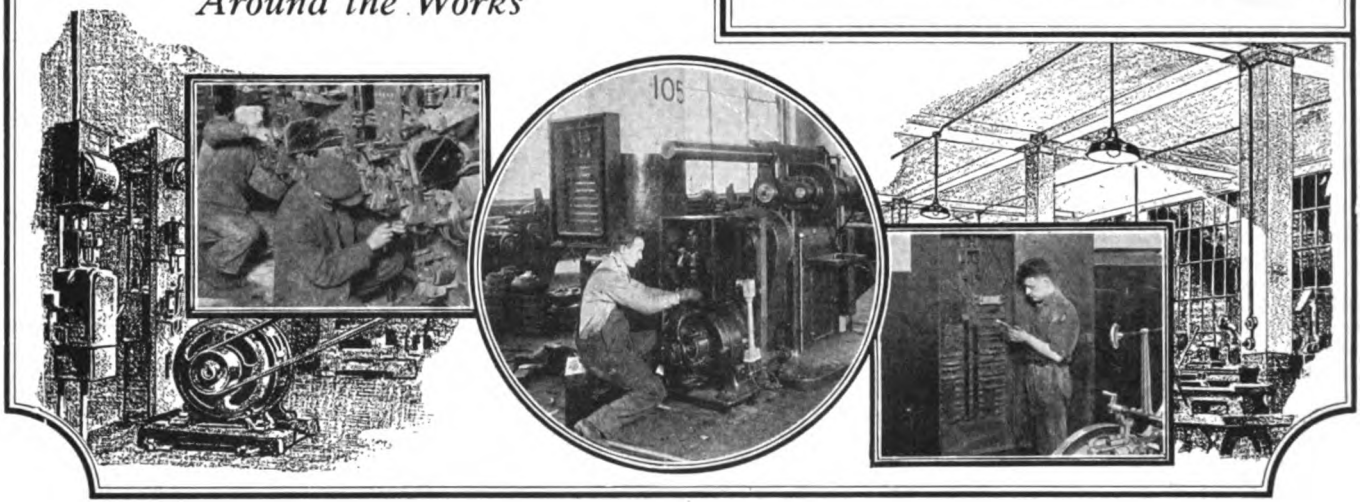
Chief Electrician, R. M. BUSH.
Tubige Artificial Silk Co.,
Hopewell, Va.

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Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Factors Involved in Layout of Lighting System for Pattern Storage Building

ASIDE from the illumination requirements, the design of lighting systems for pattern storage buildings should receive special consideration from the engineer, due to the great fire hazard that is involved. Pattern storage buildings are built without windows, to reduce the fire risk. Therefore, natural light need receive no consideration in the illumination design. In this application, as in every other, electric lighting has replaced oil and gas for illumination where full consideration has been given to the lighting problem. It is more convenient, less expensive, and very much safer than any other form of illumination.

In the modern, re-enforced concrete, pattern storage building none of the floors or rooms is connected with any other; there are no halls, stair wells, nor elevator shafts within the building. Stairs and elevators are on the outside of the building, and all doors are of fireproof construction, each with a second door inside the wall arranged to close by gravity upon the melting of a fuse link.

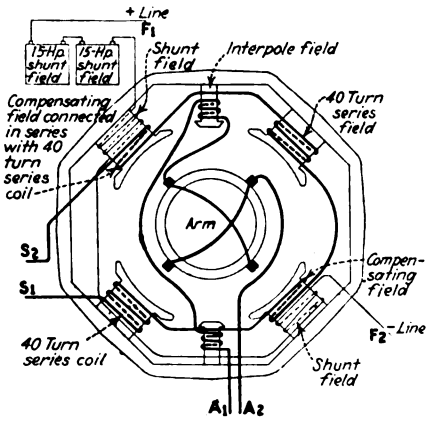
In the lighting system for this type of building there should be no switches inside the outer walls. Cast-iron enclosed, quick-break safety switches should be mounted outside on the wall near the doors. All wiring should, of course, be protected by rigid steel conduit. All lamps should be protected from breakage by very strong, specially-constructed steel guards to prevent the destruction of the lamps and perhaps damage to the sockets. A large pattern striking against an unprotected lamp might result in a flash due to the conducting parts of the socket coming in contact and so set fire to the pattern and perhaps the building.

Special lighting designs are recommended for pattern storage buildings as a form of insurance which, at a low cost, will prevent fire losses which might otherwise result from poor construction and installation.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

Emergency Method of Operating Shunt Motor Having Grounded Field Coil

AN APPROACH table to a shear handling strip from the hot bed of a hot strip mill was operated by a 20-hp., 230-volt, direct-current, shunt motor, controlled by a reversing drum controller having five points. In spotting the steel to obtain the proper length for shearing, much plugging is necessary. Endless trouble was experienced with this drive as it was subjected to plugging voltage which may run up to almost twice normal voltage and which caused field and armature failures to ground.



The two defective shunt-field coils were replaced with series coils wound with 40 turns of wire.

These were connected in series with the compensating windings so as to give additional series characteristic to the motor fields. The two remaining shunt-field coils were placed on opposite poles and connected in series with two 15-h.p. shunt-field coils placed outside of the motor and which were intended to limit the shunt-field current to somewhere near normal.

Due to the fact that this motor was to be replaced by a compound-wound, mill-type motor, with automatic control, no spares were available or on order. Under such circumstances it was only natural that this equipment should fail and leave us in a bad way at an inopportune time. Two shunt-field coils grounded, burning the wire in such a manner that repair without complete rewinding of the coils was impossible. In order to keep the mill in operation it was necessary that this shear table be made to run, hence it devolved upon us to find a method of repairing this motor in very short order.

The two defective shunt-field coils were removed and the remaining two good field coils were placed on opposite poles in the motor as it was believed that better flux distribution would be obtained in this manner. In series with the two good field coils were connected two shunt-field coils from a 15-hp. motor of similar make, as is shown in the accompanying diagram. The two 15-hp. shunt coils were used outside of the motor as shown, and were intended merely to act as resistance to limit the field current to somewhere near normal. Resistors could have been used, if available.

A permanent resistance was then placed in series with the armature to hold the speed down to normal, for the motor ran fast due to the full action of only two field poles and the induced field of the other two poles. Because the friction load was small (16 amp.) in comparison to the rating of the motor (80 amp.), the reduced voltage at the brushes (166 volts) due to the permanent resistor caused no trouble. Although the brushes sparked considerably, it was not enough to prevent temporary operation of the machine

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while proceeding with the winding of series coils for the field.

Not having any wire of suitable size to rewind the shunt-field coils, and believing that more series characteristic would be helpful, it was decided to make two series coils to use in place of the defective shunt coils. These were made up by winding 40 turns of two No. 8 d.c.c. wires in parallel. Each layer of wires was, of course, insulated.

These two series coils were then placed on the two field poles from which the defective shunt-field coils had been removed and connected as shown in the accompanying diagram. After the installation of these series field coils, the sparking at the brushes practically stopped. Also the motor speed was slowed down enough so that the series resistance in the armature lead was no longer needed and hence discarded.

The motor operated satisfactorily in this manner for nearly two months without failure; in fact, it operated until replaced by the new mill-type, compound-wound motor.

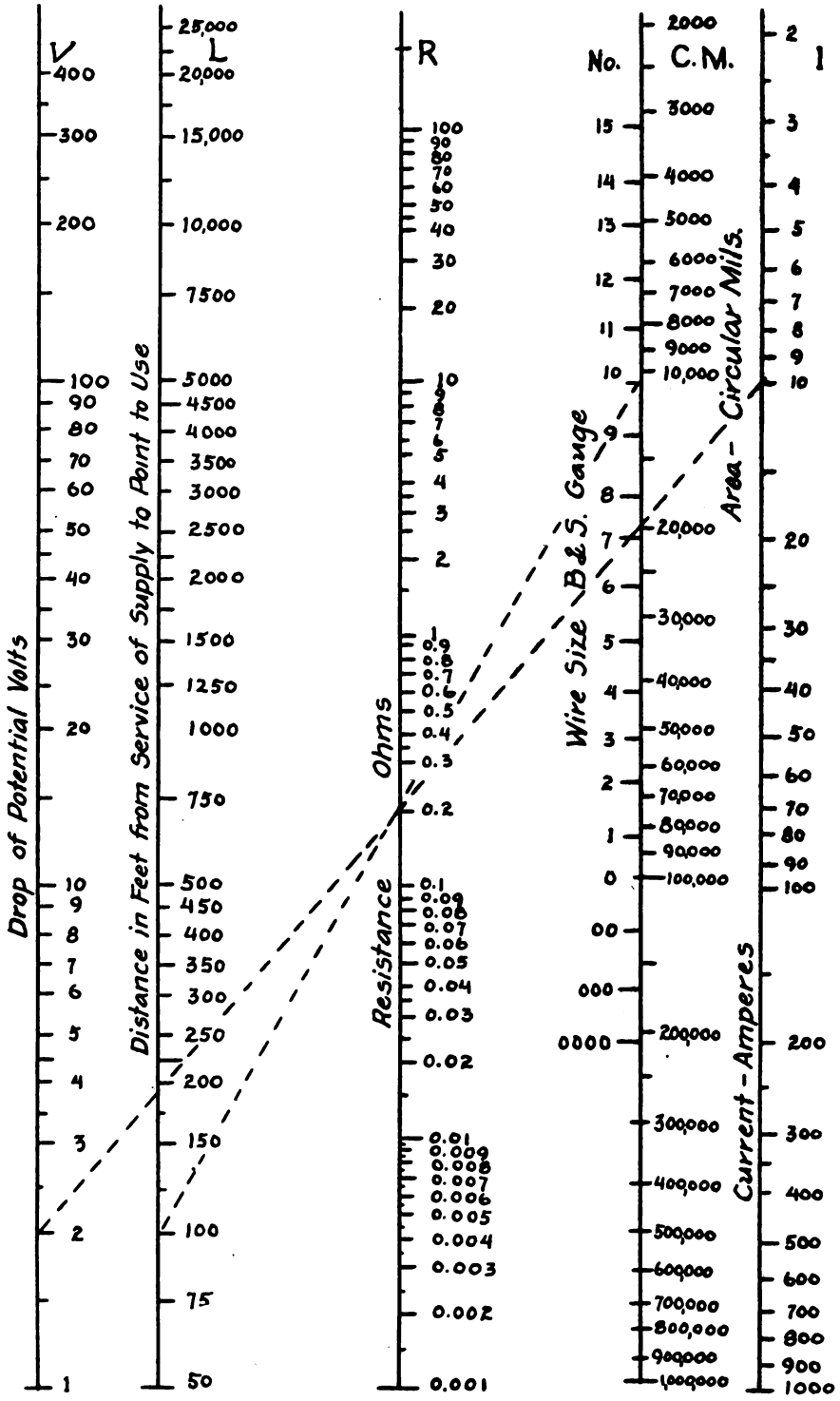
Chief Electrician, Laclede Steel Co., Alton, Ill. L. P. STAUBITZ.

Chart for Calculating Proper Size of Copper Wire

IN CALCULATING the proper size of wire to be used for a given installation, consideration must be given to the distance from the source of supply to the point of distribution, the number of amperes to be carried, and the permissible voltage drop between the source of supply and the point of distribution. The formula that is commonly used for determining wire size is as follows: Circular mils = [feet (supply to distribution) × 2 × 10.7 × amperes] ÷ volts lost. Quite often it is inconvenient to go to the trouble of multiplying and dividing all the factors given in the above formula; so the chart shown in the accompanying diagram was prepared for the purpose of eliminating the labor of these computations.

In this diagram it will be noticed that there are five scales. The first one at the left which is marked *V* represents volts and is the permissible drop of potential between the source of supply and the point of distribution. The second scale at the left is marked *L* and represents the distance in feet from the source of supply to the point of distribution. The middle or third scale is marked *R* and is calibrated in ohms. The fourth scale is marked *C.M.* and is calibrated in wire sizes and circular mils area of the conductor cable. It represents the proper wire size that is the result of the computation. The fifth scale or the one at the extreme right is marked *I* and is calibrated in amperes.

Assume that we have a direct-current motor that takes a full-load current of 10 amp. and that this motor is situated at a distance of 100 ft. from the source of supply. Also, assume that we desire that the voltage drop from the source of supply to the motor shall not exceed 2 volts. Place a straight edge on 2 volts on the drop of potential or *V* scale at the extreme left and also have it line up with 10 amp. on the current or *I* scale at the extreme right. On the middle scale, *R*, we read 0.2 ohms. In other words, if we have a drop of potential of 2 volts and a current of 10 amp., the resistance of the circuit will be 0.2 ohm. Now place the straight edge on 0.2 ohm on the *R* scale and upon 100 ft. on the *L* scale, the second scale from the left, and on the wire size or *C.M.* scale



To find size of wire to carry 10 amperes a distance of 100 ft. with a 2 volt drop of potential, place a straight edge on 2 volts on V scale and 10 amperes on I scale and read 0.2 ohms or R scale, as shown by dotted line. Now place straight edge on 0.2 or R scale and 100 ft. on L scale and read No. 10 as size of wire on C.M. scale.

By means of this chart the proper wire size for a given installation may be quickly determined as shown by the example at the bottom of the chart.

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read the size of wire, which is No. 10. Consequently, we find that a No. 10 wire is required to transmit 10 amp. a distance of 100 ft. with a drop of potential of 2 volts.

The current that is to be carried by the wires can usually be determined from the nameplate of the machine to which the wires are to be connected. In the case of direct-current machines, the current will be given in amperes and in the case of alternating-current machines, particularly two-phase and three-phase machines, the current will be given in amperes per terminal These values of current are the ones that should be used in calculating the size of wire.

In case the current is not given but the horsepower or kilowatts and voltage are given, the current can readily be calculated from the following formulas:

For direct current, $I=W\div V$.

For single-phase alternating current, $I=W\div(V\times P.F.)$

For two-phase alternating current, $I=W\div(2\times V\times P.F.)$

For three-phase alternating current, $I=W\div(\sqrt{3}\times V\times P.F.)$

In each of the above formulas I stands for current in amperes, W = watts, V = volts and $P.F.$ = power factor expressed as a decimal rather than in per cent. Horsepower can be converted to watts by multiplying by 746 before using in the formulas.

To find the best size of wire to use for balanced three-phase, three-wire circuits, the current per terminal or current in each wire is determined as described in the foregoing. The wire size is then calculated by means of the chart in the same manner as given in the previous examples. The circular mill area of the wire size thus found must then be divided by 1.154 or multiplied by 0.866 to obtain the correct size of wire for use on a balanced three-phase three-wire circuit.

In using the accompanying chart it should be remembered that distance is taken as the number of feet from the source of supply to the point of distribution or point at which the wires are to be run, rather than the total length of the wire that is used.

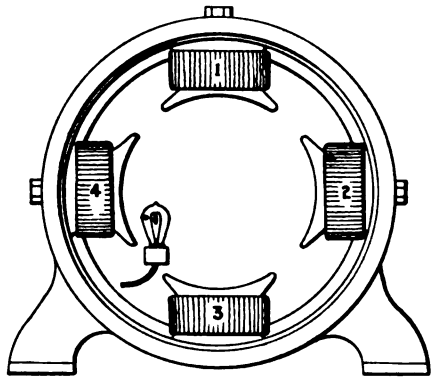
CHARLES F. CAMERON.

Rock Springs, Wyoming.

Locating Reversed Field Coil With Carbon Lamp

SOME time ago while running a test on a synchronous motor, which had just been installed, it was noticed that the direct-current machine which was to be used to furnish current for excitation and to bring the synchronous motor up to speed, would not accelerate and that it sparked badly at the brushes. Shifting the brushes did not remedy the trouble. The wiring connections were checked and found to be correct; also the connections inside the motor exciter were checked and found to be all right. It was then decided to test the field coils for polarity; so the armature was removed. The question then arose as to how the polarity of the field coils could be checked, as a compass was not available.

This difficulty was overcome by using a carbon lamp in the following manner. One side of the globe of a 16-cp., carbon lamp was marked with black shellac as shown in the sketch and connected to an extension from the direct-current, plant lighting system. The shunt-field coils of the exciter were now energized from the switchboard and the carbon lamp placed near the pole face of each coil in succession with



The filament of a lighted carbon lamp is attracted or repelled by the field pole.

By holding the lamp in the same relative position over the face of each pole, the polarity of each pole relative to the remaining poles, can be determined.

the marked side of the globe towards the pole face. By watching the lamp filament closely it was noticed that at the first coil the filament of the lighted lamp was deflected toward the pole; at the second pole it was deflected away from the pole; at the third and fourth poles it was also deflected away, which showed that there were three field coils in succession having the same polarity. In other words poles 2, 3, and 4 were either all north poles or all south poles. The connections of the coil on No. 3 pole were reversed and the machine reassembled, after which it ran in an altogether satisfactory manner.

The reason the lighted lamp acted in this manner was because the carbon filament carrying direct current acted as a small electromagnet which was attracted or repelled when brought close to a shunt field pole. The black spot was placed on the lamp to insure that it was held in the same relative position in front of each pole. If the lamp filament were repelled by a north pole when the black spot was towards the pole it would likewise be repelled from a south pole if the black spot were away from the pole. Hence the necessity for putting the black spot on the lamp.

Later, this same test was applied to the field of an 85-kw. synchronous motor by connecting a 32-cp. carbon lamp in series with the field. Even with this small amount of current flowing—about 1 amp.—the indications were quite clear. The best results are obtained by holding the lighted lamp over the face of the pole and momentarily turning off the current to the lamp. Then each time the current is turned on the filament will move sidewise, thereby indicating the relative polarity.

New Westminster, B. C. W. L. STEVENS.
Canada.

Method of Making a Sleeve Splice on Heavy Cables

UNDER the above heading there was described by S. H. Samuels on page 153 of the March issue of INDUSTRIAL ENGINEER, a method of splicing a 500,000 circ. mil. cable which, although a sleeve was used, differed considerably from the ordinary sleeve splice.

The method described was to cut the heart out of one section of the cable for a distance of a few inches, leaving only the outer strands. The other section of cable was treated in just the opposite manner—the outer strands being removed and the inner ones left. The result, when the inner strands of one piece had been pushed inside of the outer strands of the other and the two sections butted closely together, was a dowel joint, which was reinforced by a split sleeve around the outside. The joint was then soldered and insulated.

While such a joint is an improvement, for large cables, over the ordinary sleeve joint (where the ends of the wire are merely butted together inside of a split sleeve and then soldered) and should be perfectly satisfactory in places where there is no strain on the cable, which the writer of the article said was the case in this instance, yet it is not the safest one to use with heavy cables that are under a strain. I have known of cases where very similar splices have pulled apart.

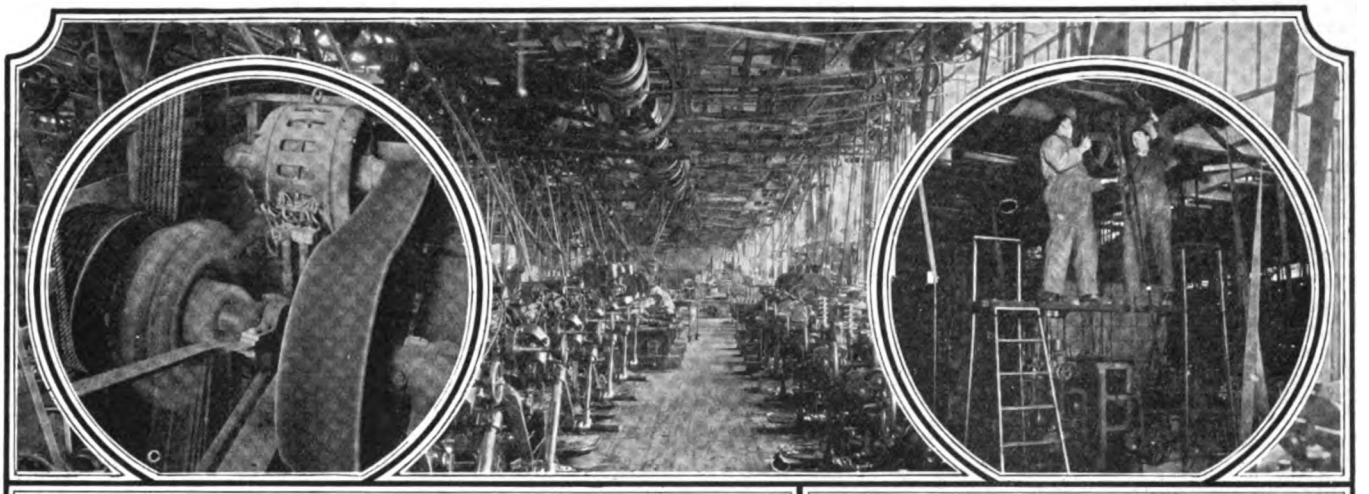
Under a strain, the ordinary mechanical joint of the Dossert or some similar type, should show up better; best of all, in my opinion, would be the ordinary wrapped joint.

This is made by first cutting back the insulation, on each of the sections to be spliced, for several inches. Then, for about half of this distance the heart is cut out of both of the cables to be spliced. The outside layer or layers of wire are fanned out at right angles to the axis of the cables and the ends of the two cables are butted closely together, the strands being interlaced and brought down to their original positions. Next, one of the strands is wrapped tightly around all of the other strands, which are bunched together. After this strand has been wrapped as far as it will go, another strand is taken and similarly wrapped. This procedure is followed until all of the strands have been used. When the work is completed you will have, if the splice had been well made, a joint which even before soldering will be mechanically strong and electrically of very low resistance.

However, soldering will increase both its mechanical strength and its electrical conductivity, and should be done in all cases. Instead of heating the wire directly by means of a blow torch it is better to bring the wires up to the required temperature by pouring the molten solder over the joint, from one ladle to another, after the use of the proper flux. By pouring the solder over the joint the wires will be kept cleaner than if the flame impinges directly upon them.

Westfield, N. J. G. H. MCKELWAY.

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Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Standardized Type of Platform for Mounting Motors on Columns

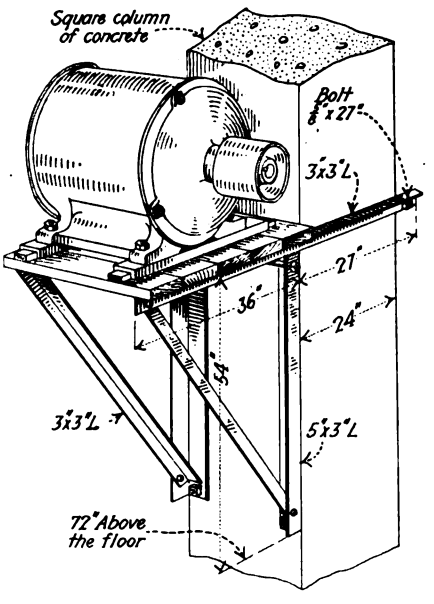
RECENTLY a large fireproof warehouse was taken over by an industrial firm for manufacturing operations and group motor drives were installed at various points. The building had a 30-ft. bay along each side and a 12-ft. aisle through the middle. It was desired to put the motors in this aisle where they would be more out of the way, would not shut off any light, and where they could be fed from a common power line down the center of the room. However, it was desired they be accessible, substantially supported, not interfere with trucking operations, and that their installation cost be low.

The man at the head of the millwright and maintenance departments decided upon the motor stand shown in the accompanying illustration. As more than a score of them would be required, he decided to reduce the manufacturing cost by making only one type and size of stand, regardless of whether a 5- or 20-hp. motor was to go on it. It was decided to attach the motor stands well up toward the ceiling on the 24-in. by 24-in. reinforced concrete columns alongside the aisle.

These stands were made of angle iron, which is the simplest and strongest form in which metal with the desired working faces could be secured, and were designed so that no bending or special cutting was needed for fabricating. They were made up in triangular shape and riveted at the intersections. The top legs were made long enough so that a bolt could be put through the two columns, as shown in the drawing. The motors were placed on the side of the column toward the aisle; thus all of the belt pull is toward the column and the supporting frame is partially relieved of this strain.

The frames were drilled for four expansion bolts to attach them to the face of the column on the aisle side. Two of these ¾-in. expansion bolts set in lead poured in holes 4 in. deep in the column face are shown in the drawing. The use of expansion bolts necessitated a minimum of cutting on the columns. To locate these holes for drilling, the frame was placed against the column, the tops leveled up throughout, and the holes scribed and drilled.

A wooden platform of planks dressed from 2-in. stock, was laid on top of the horizontal angles and bolted to them. The motor or the motor base was then bolted to this platform. All sharp corners were rounded off and the installation given a coat of cream-tinted paint. The rows of uniform platforms, all mounted at the same height and supported by a framework below that was not designed in hit-or-miss fashion, added to rather than detracted from the appearance of the room.



This standard design of motor mounting was used for the installation of a number of motors in one shop.

Method of Repairing Roller Bearings in Loose Pulleys

EVERYONE who has seen the inside of a silk throwing mill will remember the long rows of machines, each with scores of spindles and as many spools of silk cord being rapidly unwound. Though apparently the lightest of work, a room 100 ft. long full of these machines, and with 20-ft. machines set in a double row, may require 100 hp. The belt drive to these machines is received by what is known as the "head," which is really a tight-and-loose-pulley arrangement for two belts with one loose pulley. Many of these machines have 1⅛-in. shafts and the loose pulley has a 3-in. hub length. All modern machines have a roller bearing on this pulley, which greatly reduces the maintenance cost over that of the older, plain bearings.

One mill that was newly built and newly equipped began to think it was free from the loose-pulley curse as, year after year, these roller-bearing pulleys ran smoothly. Then, as if by common consent, trouble appeared on several machines at the same time. Investigation showed that the cages of the bearings had long since come apart and that the rollers had been running around freely until they packed and jammed, along with miscellaneous bits of metal, and refused to go any further.

No spare bearings were on hand. What little thought had been given to this contingency was that the bearings would wear out gradually and would show this letting down in plenty of time to order spare parts. The sleeves were good and the shafts also, but the rollers were completely "shot."

At first it was planned to put in plain bushings, and everyone mentally groaned at the thought, but the master mechanic requested to be allowed to try a home-made roller bearing expedient and his request was granted. At the present time, nearly all the machines in the mill have suffered from

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this bearing trouble and all have been fitted with these same home-made bearings; so their wearing qualities must be worth telling about.

It was found that ⅞-in. round steel would just fill the space between the sleeves and the slightly worn shaft and so pieces of cold-drawn steel were cut off ⅛ in. shorter than the hub length. Eleven of these were put in; the twelfth one missed going in by about ⅛ in., but the 11 worked nicely and they were allowed to space themselves as they would. The pulley so bushed was a good fit on the shaft. The end collars took good care of any side movement, either of the pulley or the rollers.

Two years have elapsed since the first of these bearings were "replaced." The first rollers used are now being thrown out as worn too small and in their place are inserted rollers of ⅞-in. cold-drawn tool steel, unannealed. Case-hardened rollers were tried on a few machines but they were less satisfactory than the plain cold-drawn steel, as they were warped from the heat treatment and, as a consequence, they wore out of round and wore the shafts considerably.

The rollers are sawed off with a hack-saw. Then the sharp corners are filed off in the lathe and the pieces are ready to use. The replacement cost is low and these rollers can be made up at a moment's notice.

DONALD A. HAMPSON.
Plant Superintendent.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

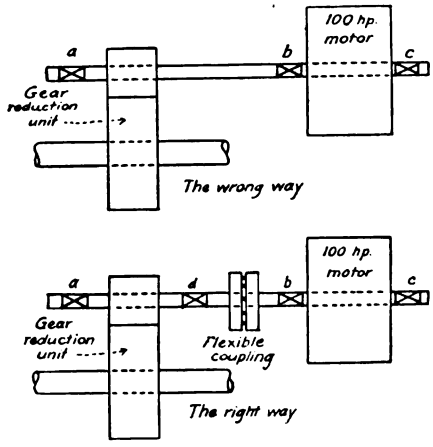
Installation of Flexible Coupling and Extra Bearing Saves $195 Yearly

FREQUENTLY plant operating men overlook the apparently small matter of placing a coupling between a source of mechanical power and a driven machine. In many cases the question is not brought up until considerable damage has been done to an expensive piece of equipment.

In 1915 our company tried some Francke flexible couplings (Smith & Serrell, Newark, N. J.) on rubber mill drives in our plant at Akron, Ohio. The value of a flexible coupling on some of the drives was so apparent that it led to additional purchases, and in 1917 we began using them at our College Point, Long Island, plant. Recently when we adopted individual drives for the Butler, N. J., plant we installed Francke flexible couplings throughout.

We manufacture hundreds of hard rubber products including a large number of radio supplies, combs, and so on. The flexible couplings are employed in driving all kinds of rubber machinery, including washers, mixers, grinders, calenders, and so on. We also employ flexible couplings on our tin mill drives.

These mills are driven by induction and synchronous alternating-current motors operating generally at about 600 r.p.m. Also, a number of variable-speed, direct-current motors, giving speeds of 300 to 900 r.p.m., are used on the finishing work or tin mill drives. Gear reduction units, most of which are of the herringbone type, with a reduction ratio of about 6 to 1, are employed on practically all drives. The flexible couplings are used between the motors and gear reduction units.



These sketches show the proper way to install a drive, with a flexible coupling between the drive and the reduction unit.

All the drives are equipped with a braking device on the motor so as to protect the operator and machine. On the d. c. motors and the a. c. synchronous machines, electro-dynamic braking is employed, while the a. c. induction motors are equipped with hand-reset, electrically-actuated, mechanical band brakes. The braking systems are adjusted to stop the machines very quickly, and so throw a severe stress on the couplings whenever the brakes are set. Starting the machines also throws considerable strain on the couplings. In spite of this severe service these couplings have stood up very well. Since they have a certain amount of spring, they relieve the shaft and the equipment of a considerable jar when the machinery is started or stopped suddenly.

A flexible coupling has many advantages over the use of a solid shaft or a rigid coupling, with which there is danger of bearing trouble, caused by misalignment after wear has set in. Such misalignment causes whipping of the shaft, with consequent additional wear. Furthermore, when herringbone gear reduction units are employed it is advisable for the shaft to have some end play, so that the gears will mesh properly; otherwise there will be considerable wear on the gear teeth. These flexible couplings permit the required amount of end play and also permit giving the armature enough end play so that it can move to its correct magnetic center. If no allowance is made for such movement a. c. motors will draw additional magnetizing current, which lowers the power factor and decreases the efficiency.

We use extreme care in lining up our machinery and, therefore, the greatest advantage we derive from the flexible coupling is the end play which it affords. However, there are times when, due to bearing wear, a shaft gets out of alignment without being noticed.

The couplings require very little attention. We inspect them every three months merely as a safety precaution to detect signs of wear on the pins, and as soon as there are any indications of more than ordinary wear we replace the pins. On some drives the pins have not been replaced for ten years.

When it does become necessary to renew parts the job can be done very quickly because the parts are interchangeable. While the savings effected by a flexible coupling, compared with a rigid one or a solid shaft, are quite difficult to calculate in every case, it is conservative to state that many of the couplings have paid their cost many times over in the repairs they have saved. These couplings can be considered in the light of insurance on expensive machinery and equipment.

A specific case which shows how these flexible couplings prove a profitable investment is illustrated by the attached diagram which shows a 100-hp. drive on a metal finishing mill. The upper sketch shows the wrong method of connecting to the gear reduction unit, which is the way it was formerly done, while the lower sketch shows the better way, as it is done now.

With the arrangement shown in the upper illustration, bearing *a* had to be rebabbitted two or three times per year, because of the whipping of the shaft. By ading an extra bearing *d*, and a flexible coupling, as shown in the lower sketch, this repair cost was cut down to almost nothing. The added investment in the extra bearing and the flexible coupling, was about $250 and the total operating cost amounts to only $51.75 per year, as shown in the accompanying cost sheet.

Savings Effected by Using a Flexible Coupling and an Extra Bearing

Fixed costs on flexible coupling and extra bearing	
Depreciation (cost + installation expenses) $250.00×10%.	$ 25.00
Average interest* on the investment at 6%=(11+10)×($250.00×0.06)+2	9.25
Estimated annual allowance for repairs and maintenance (5%)	12.50
Added lubrication cost on the one bearing	5.00
Total additional cost annually	$ 51.75
Cost of rebabbitting bearing three additional times per year—	
Labor dismantling machine each time $30.00	
Labor and material rebabbitting bearing 35.00	
Total $65.00	
Total additional cost per year—3×$65.00	$195.00
Fixed costs on flexible coupling and extra bearing	51.75
Net annual saving	$143.25
Net annual return on the added investment 57%	

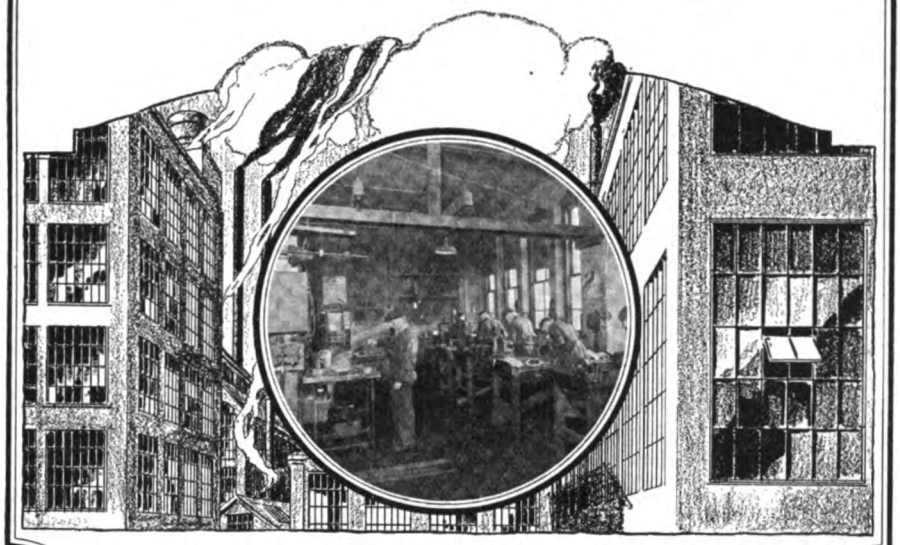
* Allowing for interest earned by depreciation reserve.

On the basis of three additional babbittings for bearing *a* each year, there is a gross saving of $195. If we subtract from this saving the cost of operating the flexible coupling and the extra bearing, *d*, there remains a net annual saving of $143.25, which represents a net annual return of 57 per cent on the investment.

Mechanical Engineer, N. A. COZZENS.
American Hard Rubber Co.,
New York, N. Y.

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In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Selecting Material for Small Motor Bearings

SOME repairmen are under the impression that small motor bearings can be made satisfactorily from any kind of bearing materials. This is not the case, judging from my experience while in charge of a repair shop handling all kinds of small motors.

We repaired all kinds of appliances having high-speed motors, such as vacuum cleaners, drink mixers, and the like, and at one time considerable trouble was encountered on account of new bearings freezing shortly after they were installed. As our shop was equipped with lathes, rush bearing jobs were turned out by one of our workmen. Many cleaners and washing machine motors came back with frozen bearings shortly after being sent out equipped with bearings of our own make. Our first thought was that the customer had failed to keep them well oiled.

New bearings of the same material were made and sent out with the same results, although care had been taken to see that they were properly oiled. We were not having trouble with factory-made bearings, which gave very good service. Upon checking up on the materials used, I found that we were making bearings from cold-rolled brass obtained from a local hardware store at a low cost. A search through our stock room brought forth plenty of good bronze bearing material in sizes best suited for our bearings. From that time on all bearings were made from this material, and there were no come-backs or complaints. A test set ran very well for hours without oil before being damaged in the least.

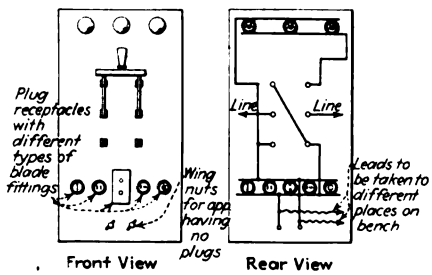
The heating of small bearings is much greater, in proportion, than in the case of large ones, due to the absence of flowing oil carried onto the shaft by rings. Therefore, a high grade of bearing material should be used on all small motor bearings, as it is the cheapest in the long run. The co-efficient of expansion of brass is higher than that of bronze, which sometimes permits bearings to freeze regardless of the amount of oil used.

Chicago, Ill. CARL G. HOWARD.

Layout of Panel for Testing Electrical Equipment

IT IS common practice in repair shops to put a lamp in series with the test leads used for detecting short-circuits and other defects in electrical equipment. The testing panel shown in the accompanying illustration has the advantage that lamps may be cut in series with the leads or full line voltage may be put on the equipment under test, by throwing over the double-throw switch. Furthermore, the lamps may, if desired, be mounted away from the panel, so that there will be much less danger of breakage, while the panel itself may be placed conveniently close.

As will be seen from the left-hand diagram, this testing panel consists of a double-pole, double-throw switch, two or three lamps and several plug receptacles with different types of blade fittings, all mounted on a suitable base. Wing nuts are provided at the bottom of the panel for connecting apparatus that is not fitted with a plug. If flush-type receptacles and a back-connected switch are used the panel will present a very neat appearance. The diagram at the right shows how the panel is wired.



When the switch is thrown up the lamps are cut into the testing circuit; when it is thrown down the lamps are cut out. The diagram at the right shows the connections on the back of the panel.

Electrician, Riordan Pulp Co., Temiskaming, Que., Can. J. H. SAUVE.

Making Quick Repair of Broken Motor Frame

WE HAD an accident in which one of the end frames of a 1-hp. motor was broken at a time when it was very badly needed. It was a single-phase, 60-cycle, repulsion-induction motor, running at 3,600 r.p.m from the lighting current supply. In a few minutes' time, we ascertained by means of a telephone that there was not another such motor in the community. The delay in sending to the manufacturer for a new end frame would mean an actual loss of hundreds of dollars.

We considered two ways of repairing the broken frame to keep the machine in service temporarily: One was to rivet on plates to hold the broken parts together, and the other was welding. We could get the parts aligned better by using patches, but it would not be as rigid a job as the weld. The break on the frame was, incidentally, on the end away from the pulley. Not only was the outside ring of the frame cracked through, but also the hub enclosing a bolt hole was broken out completely, as was the center hub housing the bearings.

We finally decided to try welding. We first welded the ring together and put in the bolt hub. Then we clamped the piece on a planer bed, blocked the center hub up on the inside on its machined face and ran a bolt down through to keep it in place. All of the welding was done from the outside. The bearing bushing and the oil ring had been removed, as had also the brush holder rigging.

In spite of the clamping, the center hub twisted somewhat when it cooled. This did not surprise us for we had noticed the same thing on other similar repair jobs. In such a case, there are two courses open in making a job that will have all the faces concentric and square. One is to bore out the center hub and make an oversized bushing for it—the frame being chucked in the lathe and trued up by the ring facing its inner shoulder. This is the method to use when the bore is badly out of line. It takes a longer time to do it, however, and requires a special bushing. The other method is to slip an arbor in the center hub, which is of the same size as the outside diameter of the bronze bushing, and to put this assembly on centers in the lathe. Then face the big end of the frame head and cut the inside shoulder to fit over the

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main body of the frame—or inside of the main body of the frame, as the construction may be.

This is what we did in the case of the motor that had been broken. The surface on the big end of the frame end ran out of line 1/8 in. Using a lathe tool, we cut until this cleared up about two-thirds of the way around the frame. The inside of this frame was bored out in the same way, not taking out all of the untrue surface but enough of it to give an average bearing so as to properly align the end frame and prevent its being sprung by the bolts.

At the same time, two inside surfaces at the hub were cut back an equal amount so that the brushes would not bind, or the rotor be unable to float in its bearings as formerly. In a little less time than three hours, we had the motor going again, almost as good as ever, and working perfectly. Such a repair is comparatively inexpensive, it makes a good job, and it saves the day where the motor is the big machine, as it most generally is.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

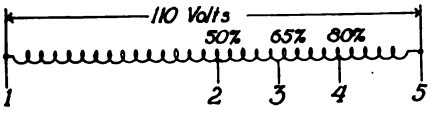
Method of Using an Autotransformer for Locating Grounds on Motors

WE HAVE found that the autotransformer from an old compensator or auto-starter can be used as a very convenient means of obtaining low voltages for testing for grounds in motors, controllers and the like. Most compensators have two or three coils placed in the same laminated frame. We use only one of these coils. This autotransformer was taken from a compensator having a rating of 5 or 10 hp., at 440 volts, although a 220-volt autotransformer could have been used. The higher-voltage transformer is preferred as it has a higher reactance and keeps the current drawn from the line to a lower value when the testing terminals are shorted, as when a ground is found.

The two line leads of the autotransformer are connected to the 110-volt supply as shown in the accompanying diagram. By connecting two test leads to the different taps of the coil, various low voltages can be obtained. Assuming that the autotransformer has a 50 per cent tap, a 65 per cent tap and an 80 per cent tap, and that the line leads of the coil are connected to a 110-volt power supply, the voltages shown in the table accompanying the diagram can be obtained.

In using the apparatus, the test leads are first connected across the tap giving the lowest voltage. The other end of one test lead is then grounded on the frame of the machine under test and the other lead connected to the winding. The ground will show up by an arc or smoke, for this method of testing permits a large current to flow through the defective part of the equipment tested. If nothing happens with the lowest voltage, the test leads may be moved to taps giving a higher voltage.

The advantage of this method over a test lamp is that the test lamp only indicates that a ground is present and does not locate its position, because the resistance of the lamp is too high to permit much current to flow through the defect, while the autotransformer will deliver sufficient current to cause the ground to smoke or arc.



To Obtain	Connect Test Leads to
16½ volts	Leads 2–3 or 3–4
22 volts	Leads 4–5
33 volts	Leads 2–4
38½ volts	Leads 3–5
55 volts	Leads 2–5 or 1–2
71½ volts	Leads 1–3
88 volts	Leads 1–4
110 volts	Leads 1–5

Test leads are connected to taps on the autotransformer, thus obtaining a low voltage for testing.

The voltage values that may be obtained with the taps indicated are shown in the table. This method of testing will pass enough current through a ground to cause it to arc or burn, thus showing its location.

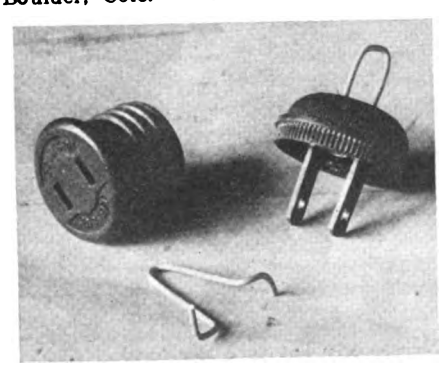
W. B. CONE.
Chief Electrician,
Shevlin-Hixon Company,
Bend, Ore.

How to Make Simple and Easily Replaceable Fuses

IN RUNNING a test on some electrical equipment it was necessary to replace blown fuses as quickly as possible, and as no circuit breaker or renewable fuse was at hand, the outfit shown in the illustration was used as a substitute and worked very well. As will be seen, caps of separable attachment plugs were fitted with lengths of fuse wire bent as shown, and the plug itself placed in the fuse block. When the fuses blew they were immediately replaced by exchanging caps. Later on the caps were refilled at leisure.

While such a fuse would not, of course, be suitable for a permanent installation, it is very useful, in emergencies, in any repair shop or laboratory. Also, it is much cheaper than the ordinary plug fuse, as the fuse wire may be purchased cheaply in rolls and cut to the desired length.

HAROLD E. BENSON.
Boulder, Colo.



Fuse wire of the desired rating is fastened under the terminals in the cap of a separable plug, which is screwed into the fuse block.

How to Clean Old Commutator Bars and Strap Copper Armature Coils

IN SMALL repair shops and winding departments of industrial plants occasions arise for removing the old insulation from a set of strap copper armature coils, or the old mica from between commutator bars, in order to reinsulate them or put in new mica.

The best way of removing the old insulation is to allow the coils or bars to soak from 4 hr. to 8 hr., depending upon their size, in a tank of boiling Wyandotte or Oakite cleaning solution. An ordinary water pail or washboiler, heated on a gas plate, may be used in the absence of a standard tank with steam coils, or other means of heating the cleaning solution.

Armature coils should be removed carefully from the armature, so as not to bend them out of shape, tied in bundles of five or ten depending on size, being lifted in and out of the tank by long pieces of scrap wire attached to each bundle. The coils should be soaked until the old insulation is soft and soggy like wet paper; then they may be removed a few at a time and the old insulation cleaned off while it is still wet. A stiff-bladed knife (one made from a power hacksaw blade will do) should be used. A scraping motion along one edge of the coil is all that will be necesary to remove the insulation. This procedure does not affect the tinning of the leads nor the copper itself, and is much better and quicker than burning off the old insulation. Burning makes the tinned ends glass-hard and warps the coils out of shape.

If the coils to be reinsulated are large and have mica and fishpaper cells in the slot sections, it is best to remove the wrappers before placing the coils in the cleaning bath. One good method of doing this is to run a glass cutter along the cell or use a sharp knife to cut along one edge and then untwist the old wrapper with the hands. It is not necessary to cut down to the copper; cut the tape and one turn of the wrapper, and then unwind the wrapper and tape. The reason for removing the cells is to allow the cleaning bath to get at the copper under the slot insulation and remove any old varnish or tape. It will be found that time can be saved by first removing the wrappers.

In the case of commutators the V-rings, mica and metal should be removed and the commutator knocked apart into a wire mesh basket. One or two pieces of mica should be saved as samples. The commutator bars should be allowed to soak in the hot cleaning solution until all the mica falls away from them. This will leave the copper clean and it will not be necessary to sandpaper any of the bars or scrape them with a knife to remove particles of mica and shellac.

A cleaning tank will be found useful for soaking small transformer cores, auto-starter cores, small d.c. armatures, with the commutator removed, to loosen up hard slot insulation and numerous other jobs around the shop.

A. C. ROE.
Wilkinsburg, Pa.

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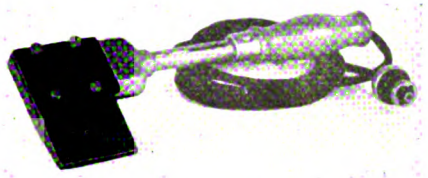
New Equipment

For Plant Operation and Maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Heavy-Duty Soldering Iron

THE electrically-heated soldering appliance shown in the illustration has been designed by Harold E. Trent, 259 North Lawrence St., Philadelphia, Pa., to meet heavy-duty requirements. It is made in two styles: a spear shape and a hatchet type. The latter is shown in the accompanying illustration. Both



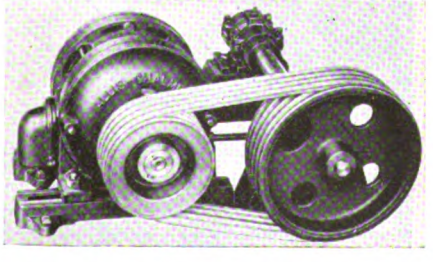
of these have a copper tip in which the heating unit is clamped and which, it is said, can be left on indefinitely at its rated voltage without overheating the tip or burning out the heating element.

The iron complete weighs 5¼ lb. and the tip is 3 in. wide by ¼ in. thick on its working surface. It has been so designed that the proportions are such as to make for easy handling. It is intended for use on 110-volt circuits and draws 500 watts.

Ten feet of the best grade of flexible cord with a two-part plug are provided to facilitate connections.

Short-Center Flexible Drive

DEVELOPMENT of a new type of short-center, flexible drive, known as the Texrope Drive, is announced by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. The Texrope Drive, as shown in the accompanying illustration, consists of a pair of grooved sheaves and a number of special endless V-belts. These sheaves are far enough apart so that the belts fit the grooves, it is claimed, without tension, slack, or lost motion in the drive. Also, that due to the V construction, they cannot slip, as the harder they pull the more firmly the belt grips the groove; however, being elastic and stretchable they do not jerk either when starting or running, nor do they transmit vibrations, but act as cushions between the driving and the driven machines.

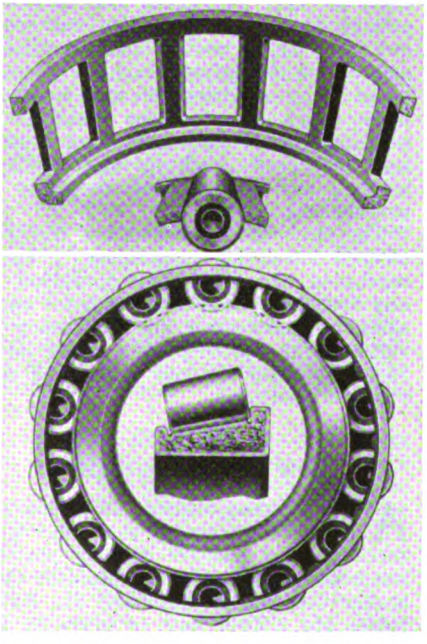


It is stated that bearing pressures are low, as no belt tension is necessary: also, that the drives occupy very little space, are silent, are unaffected by moisture or dirt, are safe and simple, and each belt carries its portion of the load.

With no slip the speed ratios are fixed. There are in use Texrope drives having ratings from ½ to 250 hp., with speed ratios, up to 7 to 1, and belt speeds ranging from 800 to 6,000 ft. per minute. They have already been placed in service in nearly every industry, particularly on textile machinery, fans and blowers, machine tools, food manufacturing machines, refrigeration, mining, crushing, wood and metal-working machinery, elevators and conveyors, paper, flour and rubber mill drives and on other appliances.

Improved Roller Bearings

ANNOUNCEMENT that an improved type of Timken tapered roller bearing is now in production is made by The Timken Roller Bearing Co., Canton, Ohio. This new bearing has



major refinements but retains all of the essential elements of the Timken bearing. It is made of nickel-molybdenum, special-formula steel. The design of the roller has been changed so that the surface of the large end presents a right-angle relation to the center line of the roll, as shown in the lower part of the accompanying illustrations. The contact between the large end of the roll and the riveted cone is in two areas. The rib of the cone is slightly undercut. This two-area contact is made to insure axial alignment between the center line of the roll and the center line of the bearing at all times. Another purpose served by the two-area contact is in maintaining alignment of the rolls on the cone in the cup, without resorting to a cage fixture to retain the alignment.

The Timken cage has been improved along with the cone and roller assembly in that all the cage pockets are made at one time by a multiple perforating die which perforates all roll pockets in the cage by a single impact. A section of cage is shown in the upper part of the accompanying illustration. Other refinements have been made in the manufacturing processes, to prevent distortion of the parts. These improvements are said to have reduced the noise made by the bearings while in operation.

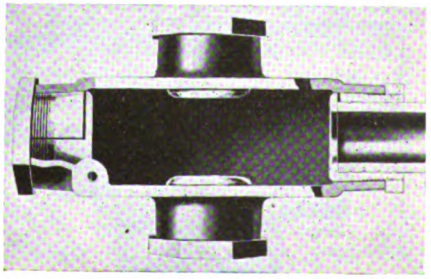
Heavy-Duty, ¼-in. Drill

THE line of portable electric tools manufactured by The Black & Decker Mfg. Co., Towson, Md., has been increased by the addition of a heavy-duty, ¼-in. drill. This model is not intended to take the place of the ¼-in. drill which has long been on the market but has been designed to supplement it. The two drills are similar in general appearance, but the heavy-duty tool is built for more severe service and operates at a higher spindle speed than the regular model.

The 3,000 r.p.m. motor can be operated on either a.c. or d.c., 110-volt current. Additional ventilating holes are contained in the rear of the motor housing. The trigger switch is used.

Threadless Conduit Fittings

A LINE of threadless conduit fittings known as Emico Kondu-Box has been put on the market by the Erie Malleable Iron Co., Erie, Pa. The Emico Kondu-Box does not require any threads on the conduit, although it can be used on either threaded or unthreaded sections. By the use of this threadless fitting the cost of thread cutting is entirely eliminated and in addition the cost of erecting or putting the conduit in place is said to be reduced owing to the fact that it is unnecessary to screw the conduit into the fitting. This box is so designed that every connection or outlet is a union in itself, which eliminates the use of running threads or units, and permits construction to be started at any point



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without resorting to a running thread. As these fittings are made of malleable iron they are claimed to be non-breakable.

The construction and method of installation of these boxes may be easily seen from the accompanying illustration. The slotted bushing which is tightened down on the conduit has rings on the interior which are forced through the enamel of the conduit as the locknut is tightened on the bushing and so make a metallic contact between the conduit and the box.

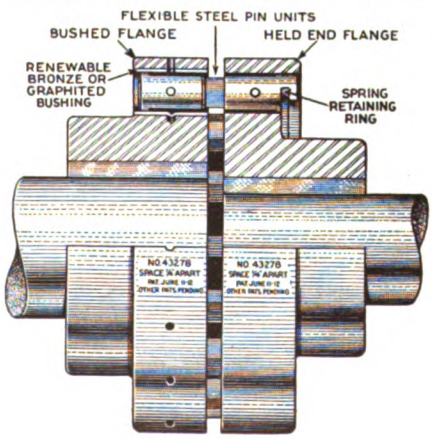
Any fitting may be removed from an installation after it has been completed so that another Kondu-Box with more openings may be substituted, without breaking the fitting. It is also unnecessary to use right- and left-hand threads, and lengths of conduit bent to any shape may be fastened together because it is unnecessary to turn the conduit in the fittings.

Another feature of these boxes is that it is impossible to lose the cover screws, as these are retained in the cover screw openings, although free to turn. In addition to the line of conduit boxes there is also a complete line of threadless couplings and adaptors for use with standard steel knockout boxes.

Improved Flexible Coupling

ANNOUNCEMENT is made of the introduction of a line of improved Francke flexible couplings for motor, turbine and engine drives, by Smith & Serrell, 26 Washington Place, Newark, N. J. These couplings will be known as the bushed-pin type in which the steel pin units are held in bronze bushings but are free to slide within these bushings.

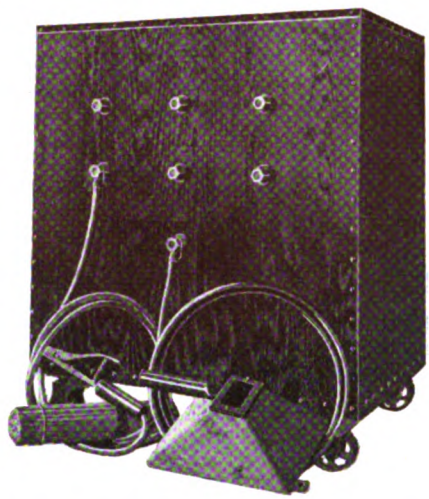
This improved Francke coupling retains many of the features of the old, heavy pattern type and has several new features which, it is claimed, give more and easier movement, increased capacity, and longer life at all speeds. Steel flanges are used for the small and intermediate sizes. Graphited bronze bushings are used in size No. 850 and larger and bronze bushings in smaller sizes are removably locked in one flange. The steel pin units are free to slide ½ in. within the bushings. It is claimed that in this way contact surfaces are more than doubled, a cylindrical surface is obtained, movement is between steel and bronze, and the graphited bushings present a self-lubricating surface that retains its lubricating qualities.



These couplings will be made in 21 regular sizes, rating from 2/3 hp. per 100 r.p.m., at 4,000 r.p.m. maximum, up to 3,850 hp. per 100 r.p.m., at 490 r.p.m. maximum, and for shafts from ¾ in. in diameter up to 13 in. in diameter.

Combination Type Arc Welder

DEVELOPMENT of a welding outfit which permits the use of both the continuous and the intermittent arc has been announced by the Electric Welding Machine Co., 1530 E. Larned St., Detroit, Mich. It is claimed



that with this combination unit the operator can obtain a continuous arc, such as is supplied by the motor-generator type of welder, for use in operations on steel and metal that is heavy enough to withstand great heat without cracking, as well as an intermittent arc, which is claimed to have greater penetrating qualities but with localized heat which permits the welding of cast-iron, hard malleable, and chilled iron, without cracking the castings welded, and without the necessity of pre-heating.

The units are known as the Weldrite electric welding machines. These machines are made for operation at any frequency and, if desired, for operation at more than one frequency or voltage, for use in plants which have, say, 220 volts in one part and 440 volts in another.

New Hoist Controller

A NEW hoist-control unit, consisting of a reversing controller with rope-operated control master station, has been developed by the Monitor Controller Co., 500 E. Lombard St., Baltimore, Md. This unit is intended for use on traveling cranes, chain and rope hoists, or similar applications requiring a compact and substantial unit possessing desirable safety features. The equipment is of standardized design and is intended for operation on direct-current and on polyphase alternating-current motors that are thrown across the line for starting.

The controller consists of two enclosed-type, double-pole, mechanically-interlocked contactors having graphite-to-copper contacts, blowout magnets and suitable barriers, all mounted on an 8-in. by 7-in. panel. The overall dimensions of the controller are 8½ in. by 10½ in. by 6 in. deep.

The control master is of the fully-enclosed, self-centering type and intended for rope operation. It is always in the "off" position, except when held forcibly by the operator in either "forward" or "reverse" position. Bosses cast on the station housing take the pull of the operating rope, and protect the contacts from any mechanical damage.

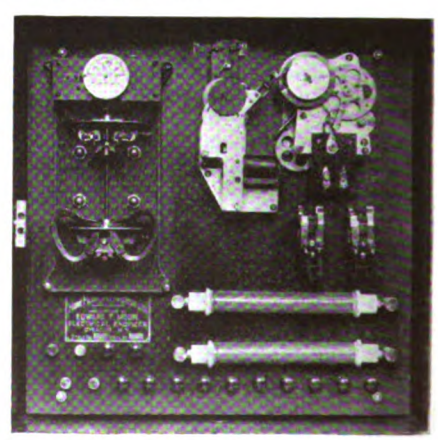
Power Demand Limitator

A NEW model of the Edmoore Demand Limitator, which is an electrically-operated device for automatically controlling maximum demands and peak loads on electric power systems, has been brought out by Edward C. Moore, Consulting Engineer, 500 Cahill Bldg., Syracuse, N. Y. This equipment automatically limits any unnecessary, unusual, or short-time power peak demands and is especially valuable where the charge for peaks drawn on "readiness to serve" is such a large fixed charge of the total power bill.

This automatic device may be set for different peak demands at different hours of the day, so as not to conflict with central station peak power demands. It is connected in the power system to cut off certain loads automatically, either wholly or in part, for short periods of time, so as to keep the demand within the limit.

The Senior Type, Model 1-A Limitator, shown in the accompanying illustration, has a wattmeter element which is connected to the current and potential transformers at the point where the power is metered on the consumer's premises, and an electromagnetic mechanism, which is actuated periodically, depending upon the period of the demand, by a set of contacts mounted in the standard totalizing watt-hour meter. It is stated that one installation used in connection with electric furnaces is saving $2,000 per month.

These power limitators may be used to control pump loads, air compressor loads, refrigerating machinery loads, heating furnace loads, melting furnace loads, and so on.



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Trade Literature

That You Should Be Familiar With

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Action Recorder—A series of bulletins describe the use of the Service Recorder for recording the operating and idle time of machinery, yard locomotives, tractors, trucks, and so on.—The Service Recorder Co., Cleveland, Ohio.

Megohmer—Bulletin B describes the use of the Megohmer for measuring insulation resistance of motors, generators, and other equipment.—Herman H. Sticht & Co., 19 Park Row, New York City.

Carbon Circuit Breakers — Circular 1705-A describes the Type CL carbon circuit breaker which is designed especially for 250-volt industrial applications.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Automatic Compensators—Bulletin 1042-E describes the line of E. C. & M. automatic compensators for automatically starting push-button operated, squirrel-cage induction motors. These are made in four standard sizes covering a wide range of motor sizes.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Portable Belt Conveyor—A group of folders describes a line of portable belt conveyors and self-feeding bucket loaders for handling, elevating, or loading loose material.—Barber-Greene Co., Aurora, Ill.

Flexible Shaft Couplings—A circular describes the Bartlett flexible shaft coupling which allows for parallel misalignment, angular misalignment, and end float.—G. M. Bartlett, 2533 College Ave., Indianapolis, Ind.

Pulling Jack—A 16-page circular illustrates a large number of uses of the Pullmco pulling jack which, it is claimed, does the work of lifting jacks, chain hoists, winches, blocks and tackle for moving heavy machinery and other weights up to 100 tons. It may be operated at six different speeds.—Puller Manufacturing Co., Inc., 600 W. 57th St., New York City, N. Y.

Wound-Rotor Induction Motors—Circular GEA-5 covers the 500 Series of wound-rotor induction motors of 10 to 150 hp. at 220, 440, 550 and 2,200 volts, for constant or adjustable varying speed and the types of control systems used therewith.—General Electric Co., Schenectady, N. Y.

Portable Hot-Job Fans—A circular describes the 24-in., 30-in. and 36-in. portable, man-cooling disk fans for cooling operators on hot jobs and for preventing hot air pockets.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Outdoor Insulating Tape—A circular describes and gives the advantages claimed for Hydro-proof tape in making splices. This tape is made of cotton sheeting which is coated with a sticky, hydro-carbon composition containing no rubber and is claimed to be rainproof and also not to dry out when subjected to hot sunshine.—Elkhart Rubber Works, Elkhart, Ind.

Acetylene Welding—A 16-page booklet entitled "Precautions and Safe Practices" covers the care and operation of acetylene welding and cutting equipment and the handling of oxygen and acetylene, as recommended by the National Safety Council and the National Board of Fire Underwriters.—Oxweld Acetylene Co., Long Island City, N. Y.

Self-Cooled Transformers—Bulletin 2046 describes the Pittsburgh film-type radiator for self-cooled transformers. — Pittsburgh Transformer Co., Pittsburgh, Pa.

Speed Recording and Indicating Instruments—Bulletin 725 describes and illustrates the Esterline-Angus speed recorder. This consists of a fully-enclosed, magneto-type generator, which generates a voltage directly proportional to the speed of rotation, and a direct-current recording voltmeter. — The Esterline-Angus Co., Indianapolis, Ind.

Safety Set Collars—A circular describes the Rex safety set collars, which are made from malleable iron in both solid or split types.—Chain Belt Co., Milwaukee, Wis.

Exhaust Fans—Bulletin 3506 describes a line of steel-plate exhaust fans which are especially adapted for removing shavings, sawdust, dust from grinding and buffing wheels, for conveying material, elevating cotton, wool, hemp, and grains, for the removal of smoke and fumes, and other similar purposes.—American Blower Co., Detroit, Mich.

Twin Type Recorder—Form 925 shows the type of double record which may be made simultaneously on a single sheet by a Twin Type recorder.—The Esterline-Angus Co., Indianapolis, Ind.

Wiping Out—or Washing?—Folder 83 under this heading discusses the value of the Thompson safety lowering switch for lighting fixtures.—The Thompson Electric Co., 1438 W. 9th St., Cleveland, Ohio.

Asphalt Paint—A circular describes the use of Valdura asphalt paint as a preservative. — American Asphalt Paint Co., 844 Rush St., Chicago, Ill.

Metal-Insulated Ovens—A circular describes the line of No-thru metal-insulated ovens for core baking, mold drying, japanning and other similar services. These ovens are made from standardized steel panels and parts which can be arranged so that the ovens can be made in increments of 1 ft. in width up to 10 ft., in height up to 10 ft., and of any depth. These may be heated by gas or oil or electricity.—The Northern Blower Co., W. 65th St. and Wheeling & Lake Erie R. R., Cleveland, Ohio.

Pressure Regulators—Bulletin 200 A illustrates and describes the line of Standard Type R oxygen regulators and also regulators and gages for gas lines for welding outfits.—The Alexander Milburn Co., 1416-1428 W. Baltimore St., Baltimore, Md.

Safety Hand Lamps and Hand Lanterns—Folder 29 and Bulletin 2081 illustrate and describe a number of types of safety hand lamps and hand lanterns for use around inflammable gases, vapors and so on.—Crouse-Hinds Co., Syracuse, N. Y.

Gravity Conveyors—Circulars describe a special type of ball-bearing roller conveyor which is constructed to stand up under all conditions and especially under heavy loads.—Standard Conveyor Co., North St. Paul, Minn.

Welding and Cutting Equipment—Catalog 6 devotes 54 pages to listing and describing the various Smith's welding and cutting apparatus and outfits, acetylene generating units and attachments and oil preheating torches.—Smith's Inventions, Inc., 2619-33 4th St., S. E., Minneapolis, Minn.

Steel Belt—Circulars describe the use of Endural endless steel belts for power transmission drives and for conveyors. These belts are made endless at the factory and are of light gage, rustless and stainless alloy. It is claimed that the edge of the belt will not cut.—The Power Engineering Co., Youngstown, Ohio.

Cutless Bearing—A circular describes the Goodrich cutless bearing which consists of a rubber-lined bearing with a helical internal groove through which water is forced. No other lubricant is required. These bearings are used in very wet places, such as in paper mills.—The Goodrich Rubber Co., Akron, Ohio.

Belt Shifters—A circular describes the Builders pull countershaft and Universal belt shifters. With this device the belt is shifted either to tight or loose pulley by pulling a small rope. —Builders Iron Foundry, 9 Codding St., Providence, Rhode Island.

Steel-Taped Cable—A 24-page booklet describes the construction, and gives specifications and other data about steel-taped parkway cable for underground transmission.—The Okonite Co., Passaic, N. J.

Indicating and Recording Instruments —Catalog 44 describes Brown indicating and recording tachometers. Catalog 74 describes Brown recording pressure and vacuum gages.—The Brown Instrument Co., Philadelphia, Pa.

Leather Belting—A booklet entitled, "Pre-Tested Leather Belting," discusses what pre-tested leather belting means to the buyer of belting and gives some of the tests made.—Chicago Belting Co., 113-125 N. Green St., Chicago, Ill.

Bus Supports and Disconnecting Switches—Bulletin B covers a line of indoor bus supports; Bulletin C, indoor disconnecting switches; and Bulletin D, outdoor bus supports.

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This equipment is for use on lines operating at 7,500 to 132,000 volts.—The Champion Switch Co., 550 Abbott Road, Buffalo, N. Y.

Belt Fastener—A circular describes the Standard self-aligning belt fastener which has special nibs which fit into the belt in such a way as to align the fastener properly ready for riveting.—The Bourne-Fuller Co., Unionville, Conn.

Inductive Time Limit Controller—Publication C-24 illustrates and describes various installations of this controller which it is claimed eliminates the use of dashpots and other mechanical means for securing uniform acceleration.—The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Dust Arresters—A group of bulletins describe the Norblo dust arrester and dust collecting systems for foundries, pattern shops, woodworking mills and for use in connection with the pneumatic conveying of materials.—The Northern Blower Co., W. 65th St. and Wheeling & Lake Erie R. R., Cleveland, Ohio.

Centrifugal Pumps—Bulletin 201 describes the single-stage, double-suction centrifugal pump. Bulletin 202 describes the single-stage, single-suction, heavy-duty centrifugal pump such as is used for handling pulp stock in paper mills and other similar lines.—Warren Steam Pump Co., Warren, Mass.

Constant-Speed D.C. Motors—Circular GEA-61 describes the Type CD, 40-deg., constant-speed, direct-current motors of 3 to 200 hp. rating, which are four-pole, shunt or compound wound, for 115, 230 or 550 volts, and the types of manual or magnetic control used with them.—General Electric Co., Schenectady, N. Y.

Power Elevating Platform Trucks—A circular describes a light-weight, power-driven, elevating platform truck which uses only one motor for propelling and also for lifting the load. The truck platform is low and of a size which enables it to be used in connection with hand-lift truck skids. — Wright-Hibbard Industrial Electric Truck Co., Inc., Phelps, N. Y.

Underground Cable Boxes—Circulars describe the Type C box which is submersion-proof and is designed for high-tension underground primaries.—The G. & W. Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Air Compressor—A group of bulletins describes the Pennsylvania portable, semi-portable and stationary air compressors, vacuum pumps and after-coolers. These compressors may be belt or engine driven, or direct connected to electric motors.—Pennsylvania Pump & Compressor Co., Easton, Pa.

Installation Tools—A circular describes four Jiffy tools for use in electrical installation work. These are: The Jiffy dipper, ceiling cutter, adjustable cutter and loom clamp.—Paul W. Koch & Co., 23 S. Wells St., Chicago.

Oil Circuit Breakers—Circular 67448-A, Class 2, describes FK-1 and FK-12-B, single-, double-, triple-, or four-pole, single-throw oil circuit breakers for use where service is severe. All types are available for manual, solenoid, or motor operation and may be either automatic or non-automatic. These circuit breakers are made for 4,500 volts, 1,500 amp., for 22,000 volt 300 amp., and for 15,000 volts at 300, 500 and 800 amp.—General Electric Co., Schenectady, N. Y.

Easily Repairable Valve—A circular describes the Flatplug valve which is so designed that the cup and seat may be easily removed and replaced with spare parts and the worn parts reground.—Scully Steel & Iron Co., 24th St. and Ashland Ave., Chicago.

Automatic Shut-off Acetylene Torches—A circular describes the Rego automatic shut-off torch which saves gas by enabling the operator to shut off the torch and light it again instantly without readjusting the valve.—The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.

Bearing Metal—A circular describes the advantages of Utility bearing metal for high-speed operation which, it is claimed, has a low coefficient of friction and can be heated to a cherry red without damage.—The Hill Pump Valve Co., 4601-27 Belmont Ave., Chicago, Ill.

Automatic Speed Control—A 28-page, well illustrated bulletin, 108, describes automatic equipment for the control of newspaper and magazine printing presses and paper calenders.—Monitor Controller Co., 500 E. Lombard St., Baltimore, Md.

E M F Electrical Year Book Sold to McGraw-Hill Company

MC GRAW-HILL Company has purchased the *E M F Electrical Year Book* published by the Electrical Trade Publishing Co., Monadnock Block, Chicago. The 1926 edition, which will be out April 1, 1926, will be edited by the staff of the Electrical Trade Publishing Co. and sold by the staffs of both organizations. Headquarters for the Year Book until completion of the 1926 edition will be at the offices of the Electrical Trade Publishing Co. in Chicago, but information and data may be secured from men of both organizations.

This standard reference book will supplement the service of McGraw-Hill electrical publications by supplying the reference information needed by buyers and specifiers throughout the industry.

Other McGraw-Hill reference publications are, *McGraw Central Station Directory*, *McGraw Electric Railway Directory* and *The Radio Trade Directory*. It is planned to extend the directory and list services into other industries now served by McGraw-Hill publications.

Robert Wolfers has joined the McGraw-Hill Company and will be in charge of directories, lists and a direct-mail department which is being developed to serve McGraw-Hill advertisers.

Mr. Wolfers was formerly connected with *The Automobile Trade Directory* and *Chilton Automobile Directory*.

Mr. J. S. Cortelyou who has for the past year been devoting his time to *The Radio Trade Directory* will in the future direct the compilation of all McGraw-Hill directories and lists. Mr. Cortelyou was associated for many years with Mr. Wolfers in the automotive directory business.

Re-Entrancy in Lap and Wave Windings

(Continued from page 583)

lead pitch is an odd number (9). The series of coils starts on bar *1* and goes through coil *A* to bar *10*, coil *J*, to bar *19*, or two behind the bar started on. Following the winding out we will encircle the armature twice and end up on bar *1* after passing through all of the coils. Thus we have two windings that are interconnected, and singly re-entrant as can be seen.

From the above and a study of Figs. 3 and 4 we can derive the following rules that apply to duplex wave windings:

(1) The total number of bars for a 4-pole winding must be divisible by 2; for a six-pole winding, the number of bars $\pm$ 2 must be divisible by 3; for eight poles the number of bars $\pm$ 2 must be divisible by 4, etc.

(2) The winding will be progressive when the plus sign is used, and retrogressive when the minus sign is used.

(3) A 4-pole winding can be either progressive or retrogressive, but for six, eight, ten poles, and so on, the plus or minus sign will be the deciding factor.

In all cases, regardless of the number of poles, the winding will be singly re-entrant when the lead pitch expressed in bars is an odd number, as 9, 11, 13, etc. The winding will be doubly re-entrant when the lead pitch, in bars, is an even number, as 8, 10, 12, etc.

From the above it follows that a singly re-entrant winding is one in which all of the coils are passed through in regular sequence before the winding closes on itself, and a doubly re-entrant winding is one in which the winding closes on itself after passing through one half the coils, as may be noted in this case, thus forming two separate windings which are not interconnected in any way.

In taking rewinding data for duplex wave windings the winder can determine whether the winding is progressive or retrogressive by selecting any one top lead and lifting two top leads on either side of this lead bar. Then with one test lead on the data lead bar, try for a light on bars *1* and *3*, to the right or left. If the third bar to the right lights out, the winding is progressive. If the third bar to the left lights out, the winding is retrogressive. By checking the lead pitch in bars, the re-entrancy of the winding can also be determined without difficulty as already explained.

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Contents for December, 1925

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

G. A. VAN BRUNT, *Managing Editor*

Volume 83 *Number 12*

Are You a Bloodhound or a Setter? 557

Using Oils and Greases for Industrial Lubrication 558

In this article, which is the first of a series, oils and greases are discussed from the standpoints of what they are, how they are prepared and factors that influence their selection and application.

Using a Graphic Meter for Setting Overload Relays 564

G. A. Sharland describes how a graphic ammeter is used by the Minnesota By-Products Coke Co., in setting overload and accelerating relays on motor controllers.

Some of the Maintenance Problems in the Small Plant 567

Maurice C. Cockshott discusses problems that have a particular bearing on production and gives suggestions on how they may be solved with a small organization.

Reducing Heat Loss from Electric Baking Ovens 573

C. D. Corwin tells how a saving of $2,200 a year was made by reinsulating four japan baking ovens in the plant of the Corona Typewriter Co.

Practical Advice on Brush and Commutator Maintenance 575

E. S. Howe discusses some of the more important factors that influence commutation, with the causes of trouble and the remedies therefor.

What Re-Entrancy Means in Lap and Wave Windings 582

A. C. Roe gives some examples and simple rules governing the relations and principles involved in connecting singly and doubly re-entrant windings.

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A New Service Given to Our Readers

IN RESPONSE to many requests, a New Equipment section has been added to the editorial pages of INDUSTRIAL ENGINEER. In this section, which will be found on page 601 of this issue, there will be presented descriptions and illustrations of new equipment which is of interest to our readers.

This new form of service is in addition to the Trade Literature section, which will be conducted as heretofore, and in which a brief description is given of all new catalogs and literature covering equipment of interest to industrial plant men.

Editorially, INDUSTRIAL ENGINEER is wrapped around the thinking and the practical details of the problems encountered by those who bear the responsibility of selecting, installing, operating and maintaining the electrical and mechanical equipment in mills and factories, regardless of the product made. It is the function of INDUSTRIAL ENGINEER to help and serve these men in every possible way to solve the many perplexing problems which come up in their work, day after day.

To this end the Editors will heartily welcome any suggestions or comments which readers may care to make regarding subjects for articles, special features, or any other form of service that would be interesting and helpful to them in a practical way.—*Managing Editor.*

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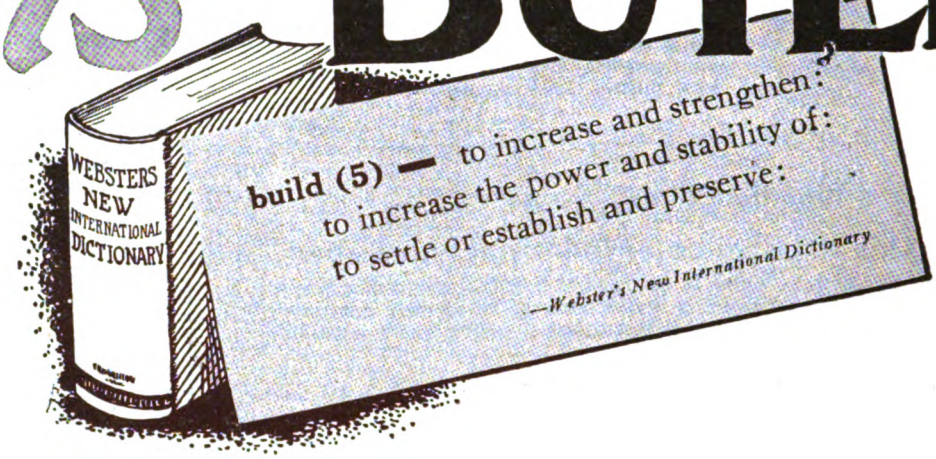
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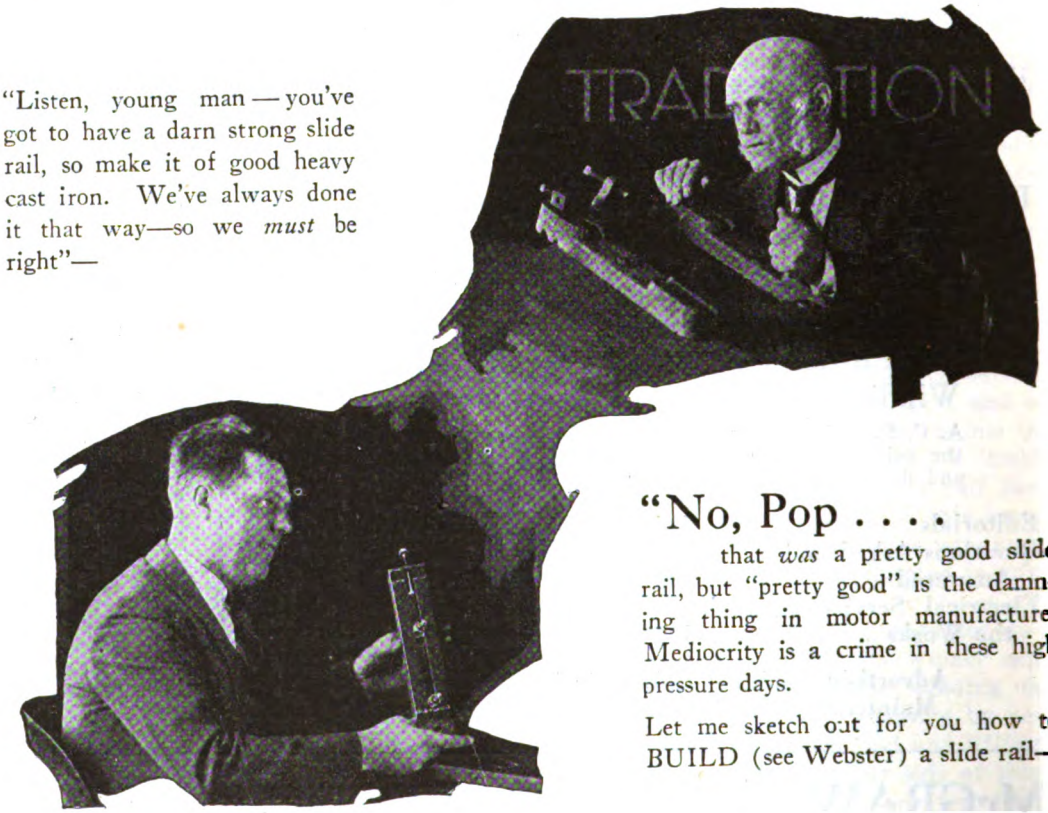
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Let's BUILD



How shall we make the slide rails?

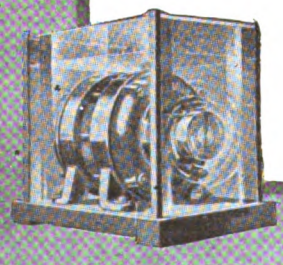
"Listen, young man — you've got to have a darn strong slide rail, so make it of good heavy cast iron. We've always done it that way—so we *must* be right"—



"No, Pop . . . .

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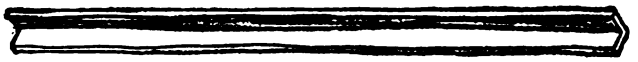


LINC

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a motor!

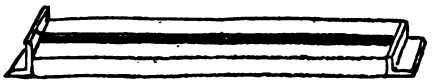
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so: 

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so: 

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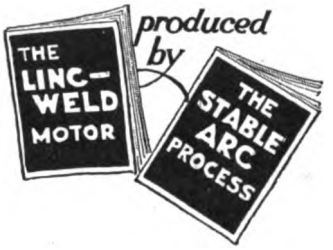
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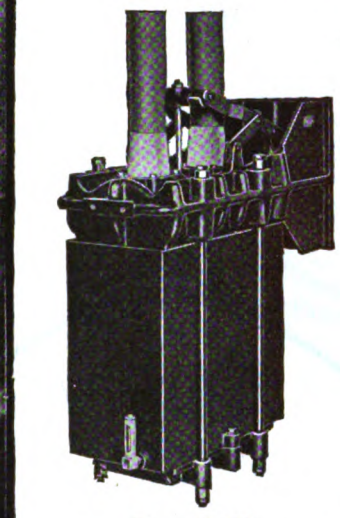
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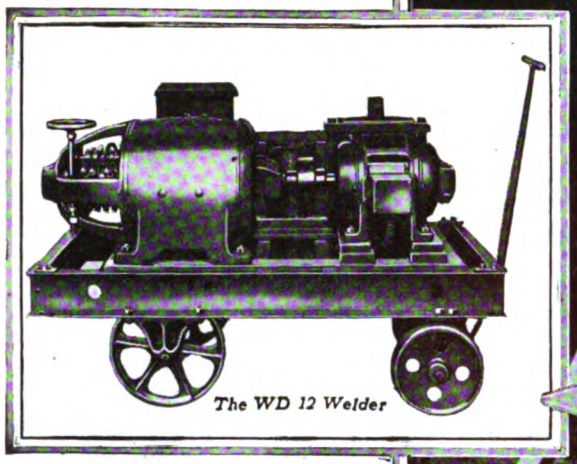
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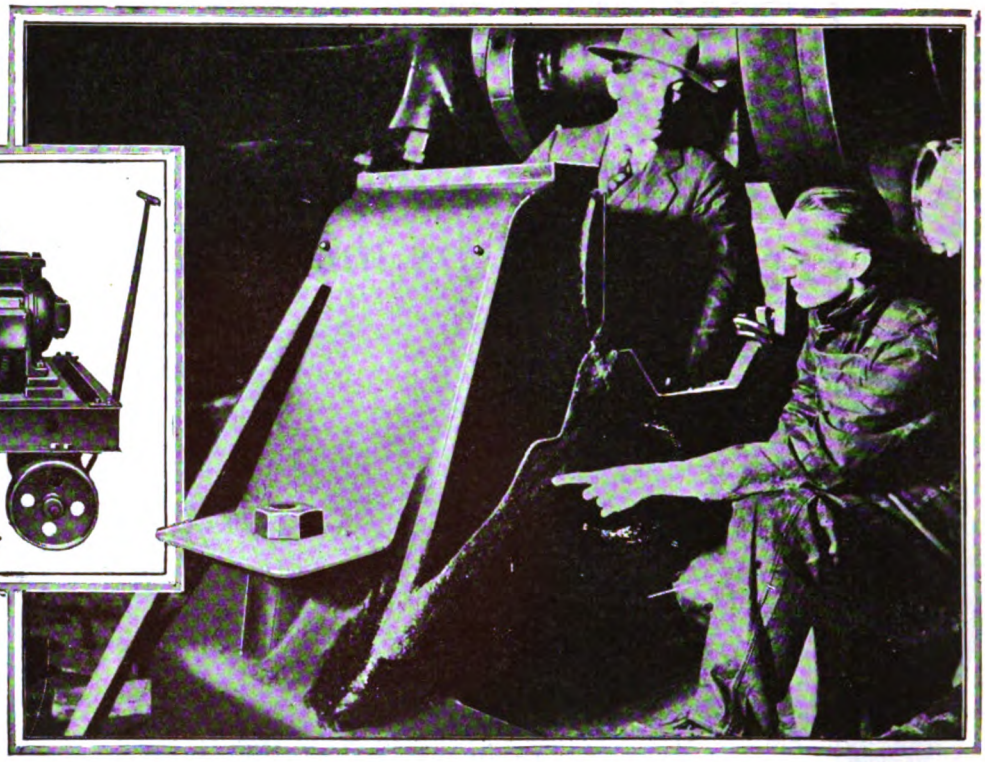
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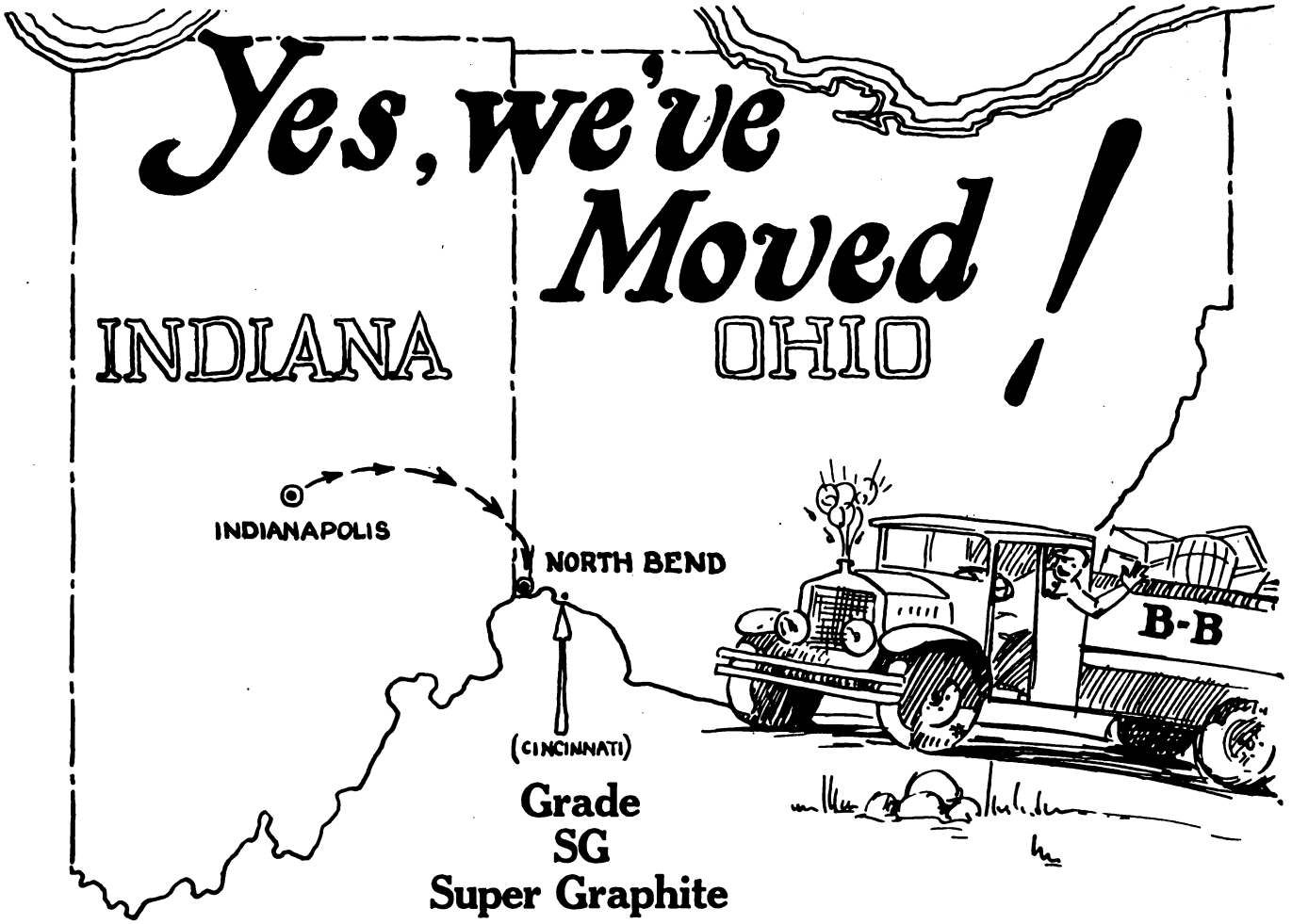
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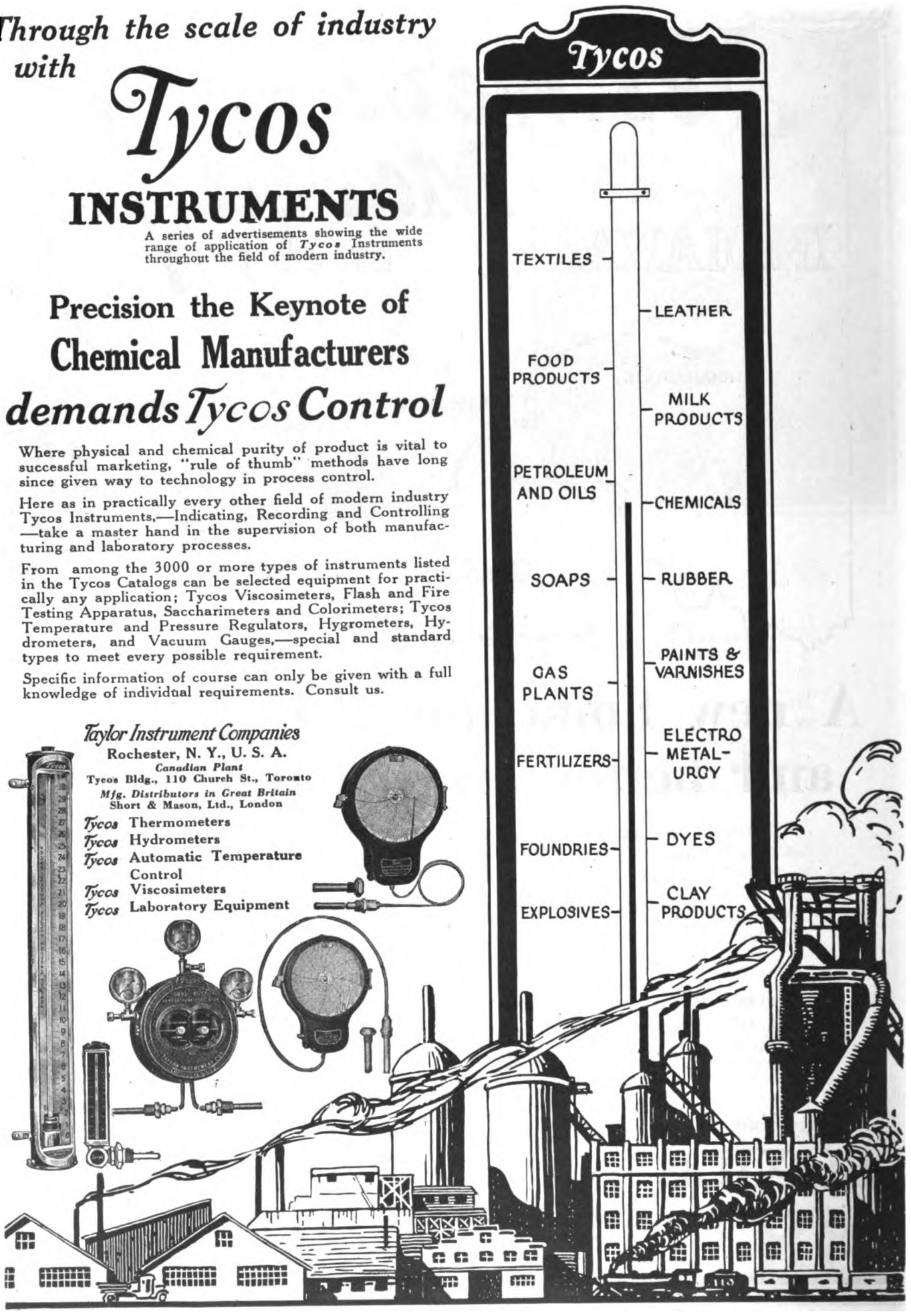
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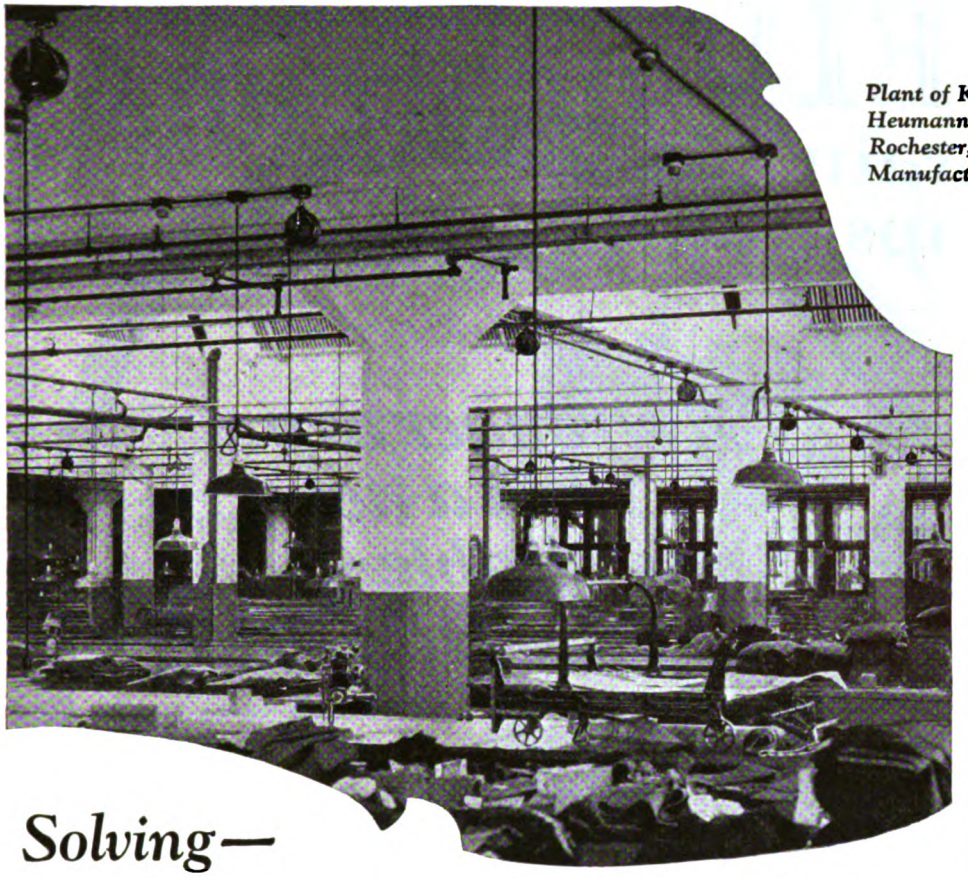
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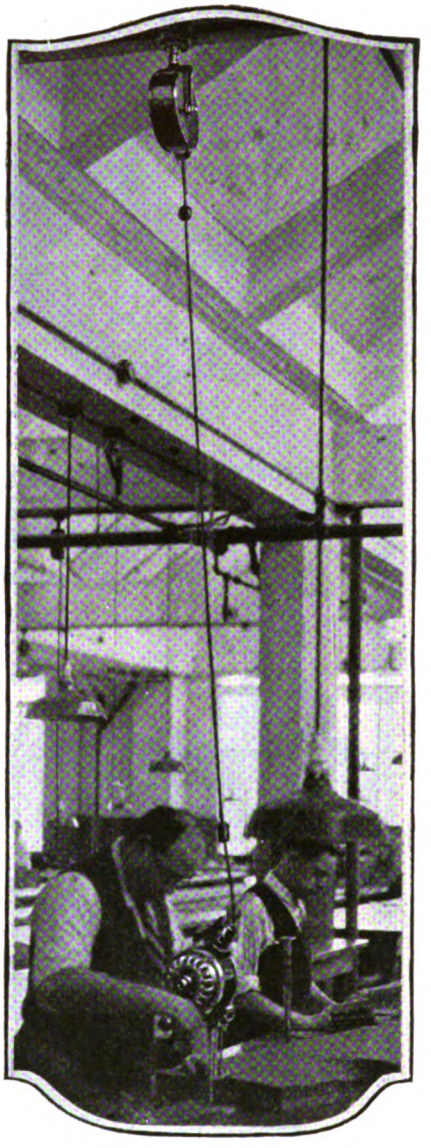


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Reelite

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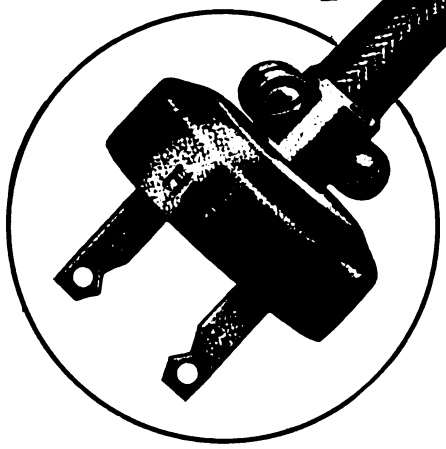


Carries Current Where Needed

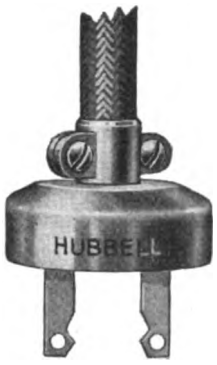
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HUBBELL

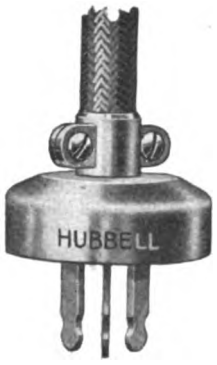
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A stronger cap with a new adjustable— clamp feature



No. 7056
Two-wire



No. 7055
Three-wire

Completely steel-armored. *Adjustable* clamp feature permits adjustment of clamp to accommodate cords of various sizes.

Takes the strain off the binding posts. Prevents plug cap breakage.

For motors, electric appliances, portable electric machinery, trouble lamps, Bell signal systems, grounding systems, portable telephones, and many other purposes.

Ask your electrical supply house for complete information and prices.

HARVEY HUBBELL INC
ELECTRICAL WIRING DEVICES
BRIDGEPORT CONN. U.S.A.
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ELECTRICAL WIRING DEVICES

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American Steel & Wire Company

VARNISHED CAMBRIC CABLE

FROM the west windows of our New York offices you get a full view of the beautiful New York Telephone Building.

The fact that a product of the American Steel & Wire Company is used in this building makes the outlook unusually interesting.

Varnished Cambric Cable, the product used to a considerable extent, was selected after careful consideration and upon the recommendation of many users. In the process of selecting a cable, the contractors received our heartiest co-operation.

The price of Varnished Cambric Cable is always right. We invite your inquiry for prices on any quantity, for any voltage and for any service condition.

Catalog on request

MADE BY

AMERICAN STEEL & WIRE COMPANY

CHICAGO, NEW YORK, BOSTON,
BIRMINGHAM, DALLAS, DENVER, SALT LAKE CITY
U. S. STEEL PRODUCTS CO.: SAN FRANCISCO,
LOS ANGELES, PORTLAND, SEATTLE



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5 FREE booklets

MAKING Conduits, Cables, and Fittings, for safe, permanent and trouble-free electrical wiring is the sole business of the National Metal Molding Company. Five of the products are fully and completely described in these booklets. Send for them.

ECONOMY Black Enameled Rigid Conduit, protected by double-dipped, acid-resisting coating of enamel—baked on.

FLEXTUBE Non-metallic, solid-wall Conduit. Never kinks! Bend it, jerk it, twist it, easily works back into shape again. The soap-stoned interior makes fishing easy.

FLEXSTEEL Flexible Metallic Conduit, pliant as a rope of woven steel! Designed to withstand weather and moisture. Of great flexibility and permanence. Full line of sizes.

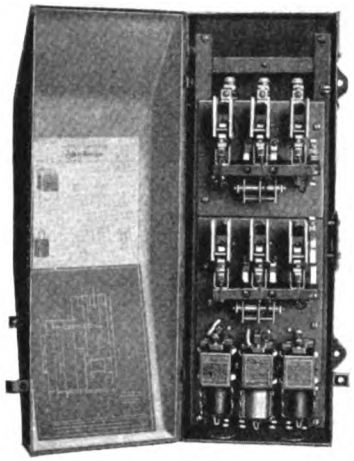
OVALFLEX A Flat Armored Cable only 5/16" thick. Bends edgewise and flatwise. Lay it on brick, tile or concrete without cutting or chipping and plaster right over it.

NATIONAL BRACKETS Designed so that wires can be attached or threaded and built to withstand excessive strain.

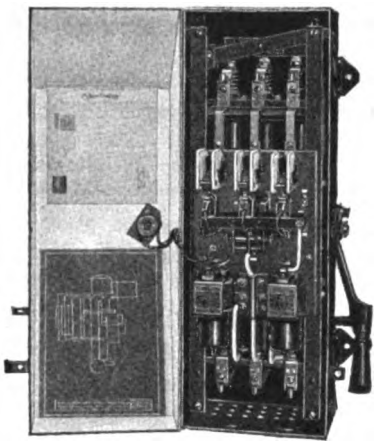
National Metal Molding Company
1581 FULTON BUILDING
PITTSBURGH, PA.
Represented in All Principal Cities (x46

National Metal Molding Company

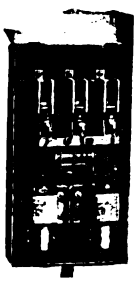
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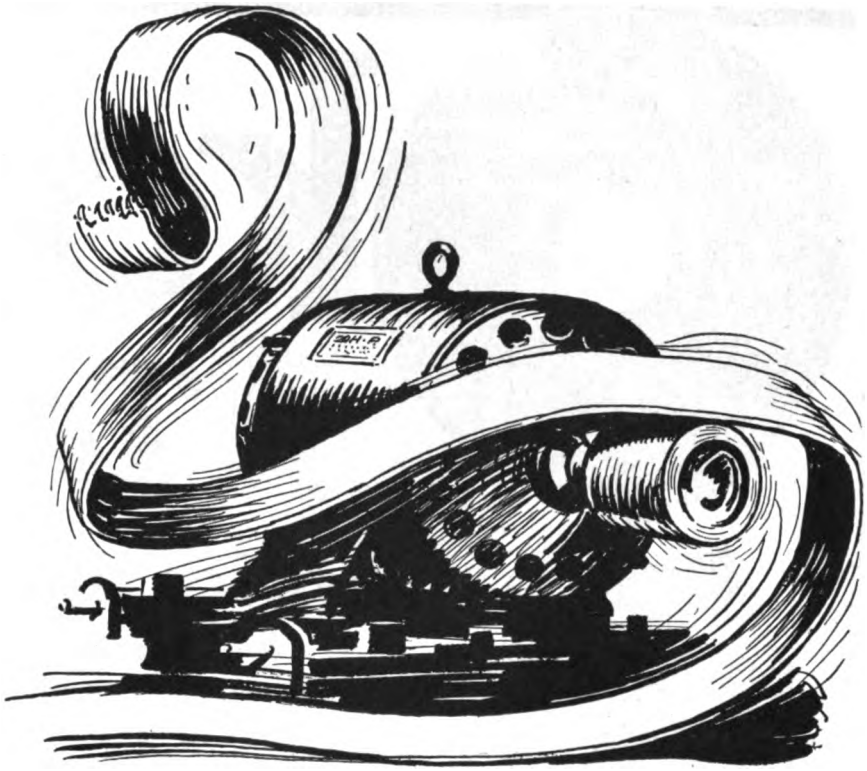
A single set screw adjusts the J-3052 Starter after installation to give desired rate of acceleration on every job.



The hand lever of the H-1852 Semi-Automatic Starter gives the operator complete control over the acceleration of squirrel-cage motors.



The J-1552 Across-the-Line Starter provides protection and convenience in starting.



Violent Starting Destroys Belts and Bearings

THE scientific selection of starters to fit machines rather than merely in accordance with motor ratings, reduces the wear and tear on belts and machinery. Accurate adjustment of starters after installation materially aids in securing economical and efficient performance.

Allen-Bradley Resistance Starters are easily adjusted to fit machines after installation. They provide smooth, gradual acceleration, which is not possible with compensators. They afford protection against overload, low-voltage, etc. They cost less than compensators.

Allen-Bradley Resistance Starters are revolutionizing motor starting. You should know about them. Mail the coupon!

Allen-Bradley Co.

ELECTRIC CONTROLLING APPARATUS

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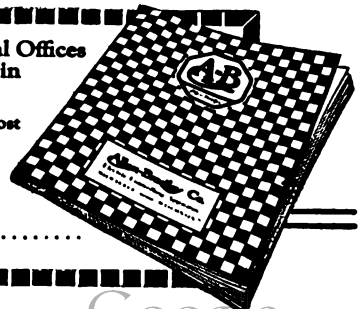
ALLEN-BRADLEY COMPANY, General Offices
491 Clinton Street, Milwaukee, Wisconsin

Gentlemen:

Of course I want to know about the most effective methods for starting squirrel-cage motors. Please forward your catalog.

Name.....

Address.....



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Okonite Tapes

Splice once and for all

WHY waste time and money trying to make permanent joints with inferior tapes?

With OKONITE TAPES you make splices *once and for all* which will be as strong electrically and as long-lived as the insulation on the wire itself.

Ask about OKONITE TAPE, the rubber insulating tape made with the same high grade rubber, compounding ingredients, and care that characterizes OKONITE insulation.

MANSON TAPE, the rubber filled cloth tape for the Mechanical protection of joints, is unequalled in weathering quality and supreme for any service where the best is the first consideration.

DUNDEE "A" and "B" TAPES, the next best friction tapes on the market, are suitable where conditions do not warrant the extra expense of Manson.

Write to our nearest Office for Samples and Booklet

The Okonite Company

The Okonite-Callender Cable Company, Inc.

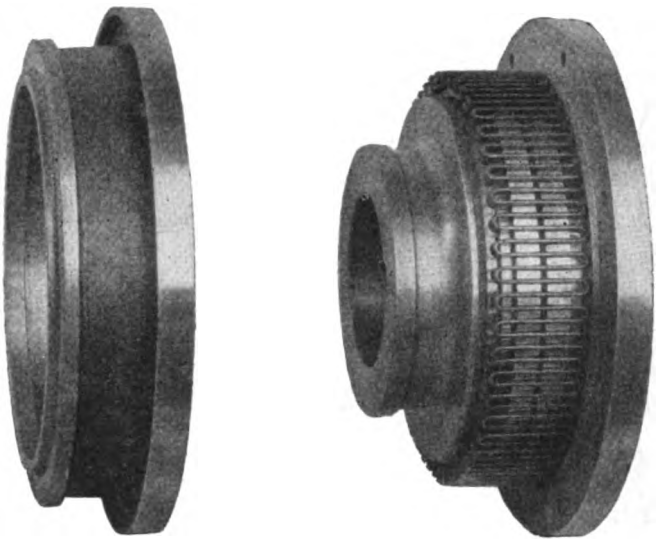
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Somewhere in Your Plant—

Somewhere in your plant there is a coupling which is not giving all the power it should, which is wearing prematurely or which is constantly breaking. The Falk-Bibby Coupling has shown remarkable efficiency under even the most trying conditions and, because of its perfect lubrication, is practically free from wear.

The greater the shocks, the more irregular the load, the more frequent the vibration, the more this coupling demonstrates its great superiority.

Write to us for information.

The Falk Corporation, Milwaukee

Representatives

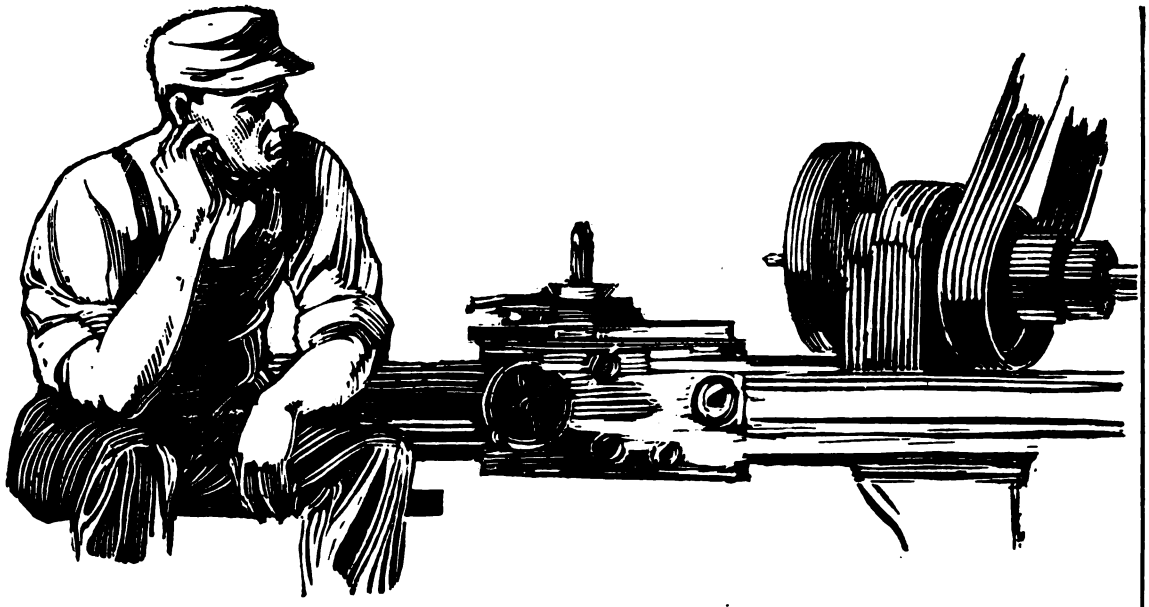
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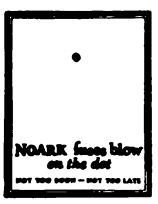
Shutdowns are holdups

LIKE the sneaking bandit who, posing as the paymaster's guard, treacherously seizes the payroll, so inferior fuses, through failure to protect the circuits they are supposed to safeguard, hold up production and often necessitate direct expense far greater than would have been the cost of using dependable NOARK Fuses.

NOARK Fuses protect and promote production, safeguard motors and lighting circuits, insure freedom from overload hazards, never blowing prematurely. They blow when—*and only when*—the circuit is menaced with real danger. That is why NOARK Fuses are known as the fuses that blow "on the dot." And because of that dependable, accurate operation, NOARK Fuses are the safest and least expensive fuses you can use.



NOARK



The Johns-Pratt Company

HARTFORD, CONNECTICUT, U.S.A.

Division of Colt's Patent Fire Arms Mfg. Company

BOSTON NEW YORK CHICAGO SAN FRANCISCO

Export Department, 30 Church Street, New York, N.Y., U.S.A.

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TRADE MARK PROTECTION SERVICE JP REG. U.S. PAT. OFF.

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J-P

has the ability and capacity to serve you in NINE ways



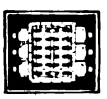
1 NOARK Fuses



2 NOARK Fuse Clips and Bases



3 NOARK Service Boxes



4 NOARK Underground Boxes



5 NOARK Universal Service Entrance Switches



6 Railway and mine material, hangers, insulators, etc.



7 J-P molding service—contract basis



8 VULCABESTON Packing—sheet, rope, braided



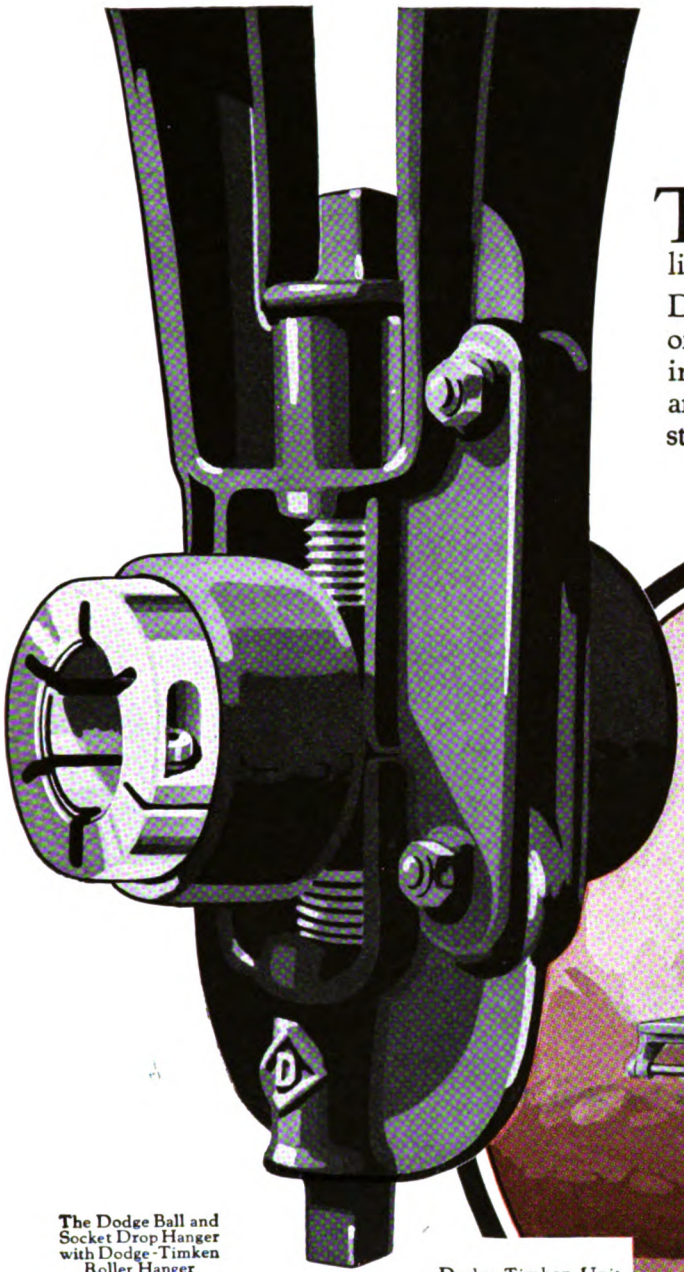
9 J-P molded radio parts—from stock

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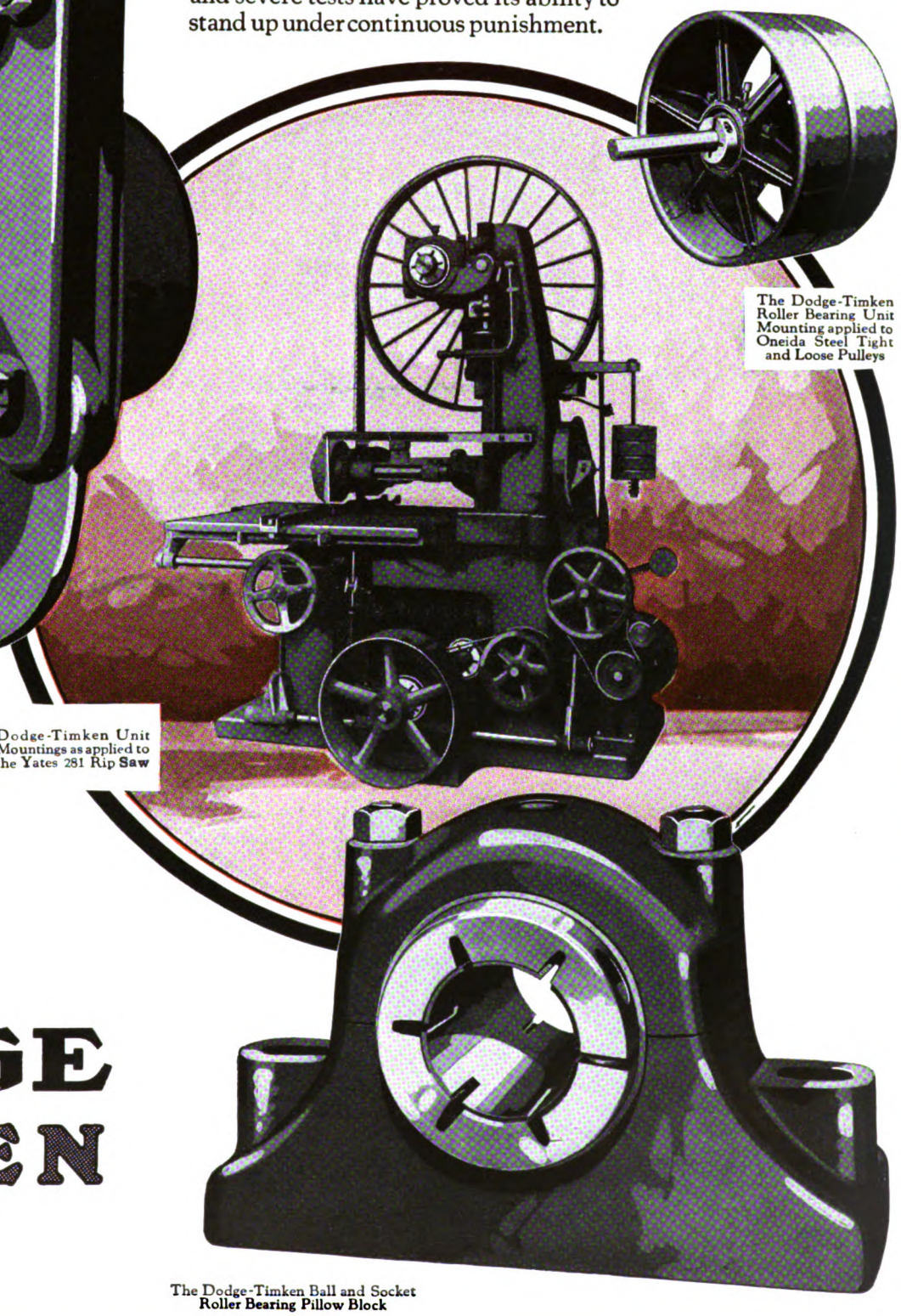
Rugged

THIS one word means more to you in terms of power savings, satisfactory, continuous operation and long life than volumes of technical description.

Dodge engineers have placed their unqualified approval on the Timken Tapered Roller Bearing as incorporated in Dodge-Timken Industrial applications because long and severe tests have proved its ability to stand up under continuous punishment.



The Dodge Ball and Socket Drop Hanger with Dodge-Timken Roller Hanger Bearing



The Dodge-Timken Roller Bearing Unit Mounting applied to Oneida Steel Tight and Loose Pulleys

Dodge-Timken Unit Mountings as applied to the Yates 281 Rip Saw

The Dodge-Timken Ball and Socket Roller Bearing Pillow Block

DODGE TIMKEN

POWER TRANSMITTING ~ ELEVATING ~ CONVEYING & SPECIAL MACHINERY

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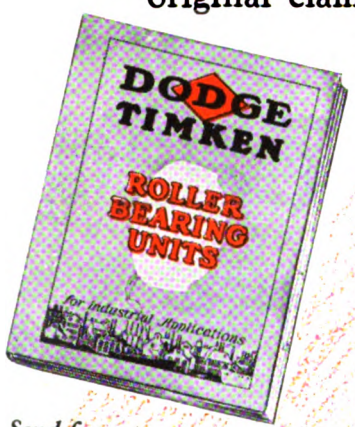
Applying the Roller Bearing to
INDUSTRIAL DEMANDS

THE endorsement of the Timken Tapered Roller Bearing for industrial applications by Dodge engineers followed the result of years of study of various types of low friction bearings under the severe conditions imposed by power transmitting and industrial service.

The Dodge-Timken Roller Hanger Bearing, which has proved every original claim in America's leading industrial plants, was followed by the Dodge-Timken Roller Bearing Pillow Block and the Dodge-Timken Tight and Loose Pulley.

The Dodge-Timken Standardized Unit Mountings for built-in applications to duplicate machinery is a further logical step in the development of a complete line of standardized low friction industrial bearings. The unit mounting permits the use of Timken Tapered Roller Bearings in duplicate machinery at a minimum engineering and production cost.

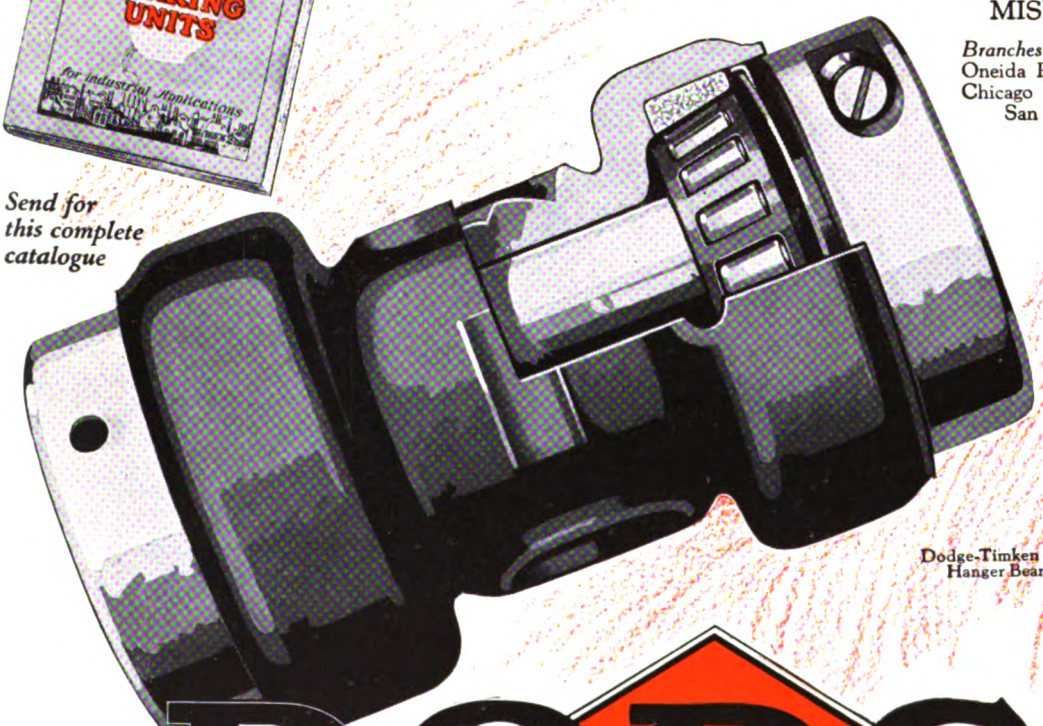
Every Dodge-Timken product is characterized by the ruggedness that means continuous power savings, trouble-free operation and long life.

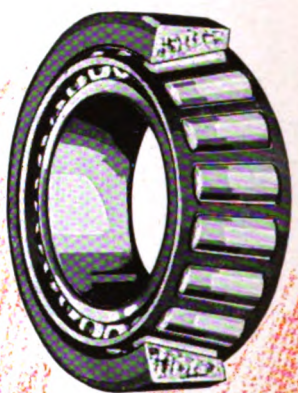


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DODGE MANUFACTURING CORPORATION
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Dodge-Timken Roller Hanger Bearing

DODGE TIMKEN

CONVEYING AND SPECIAL MACHINERY

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ELECTRICAL HEAT IN ITS MOST ADAPTABLE FORM

Now—A Better Space Heater —and at a lower price!

C-H

The C-H trademark has been a guarantee of satisfaction for more than a quarter of a century. Look for it on your new Space Heaters.



$2.00 List price East of the Rockies

SPACE heaters are the ideal solution for *hundreds of different heating problems*—their convenience, adaptability, and heating efficiency are ever widening their field of usefulness.

Now, Cutler-Hammer engineers have designed an improved space heater to meet this growing demand—improved in design and heating efficiency, *and lower in price!*

Just two feet long and easily installed, C-H Space Heaters put the heat just where it's wanted, in just the quantity that's wanted—for they may be used singly, in pairs or in groups, as required. Wherever clean, safe heat is needed—in crane cabs, watchman's houses sump pits, exposed rooms, drying and japanning ovens, detached buildings—C-H Space Heaters are the most practical and economical to use. They are ideal for foot warmers, and for innumerable other applications. Users are discovering new applications every day.



Improved design and construction throughout make the new C-H Space Heater a better heating unit. Simpler provision has been devised for installation and the resistance coil is filled with and embedded in a new refractory material which provides for better insulation of the element and quicker radiation of the heat.

One hundred and twenty-five typical applications of space heaters have been worked into a little booklet—"Dictionary of Uses". Every man in industry will find it profitable reading. Send for your copy today.

THE CUTLER-HAMMER MFG. CO.

***Works:* Milwaukee and New York**

Branch Offices:

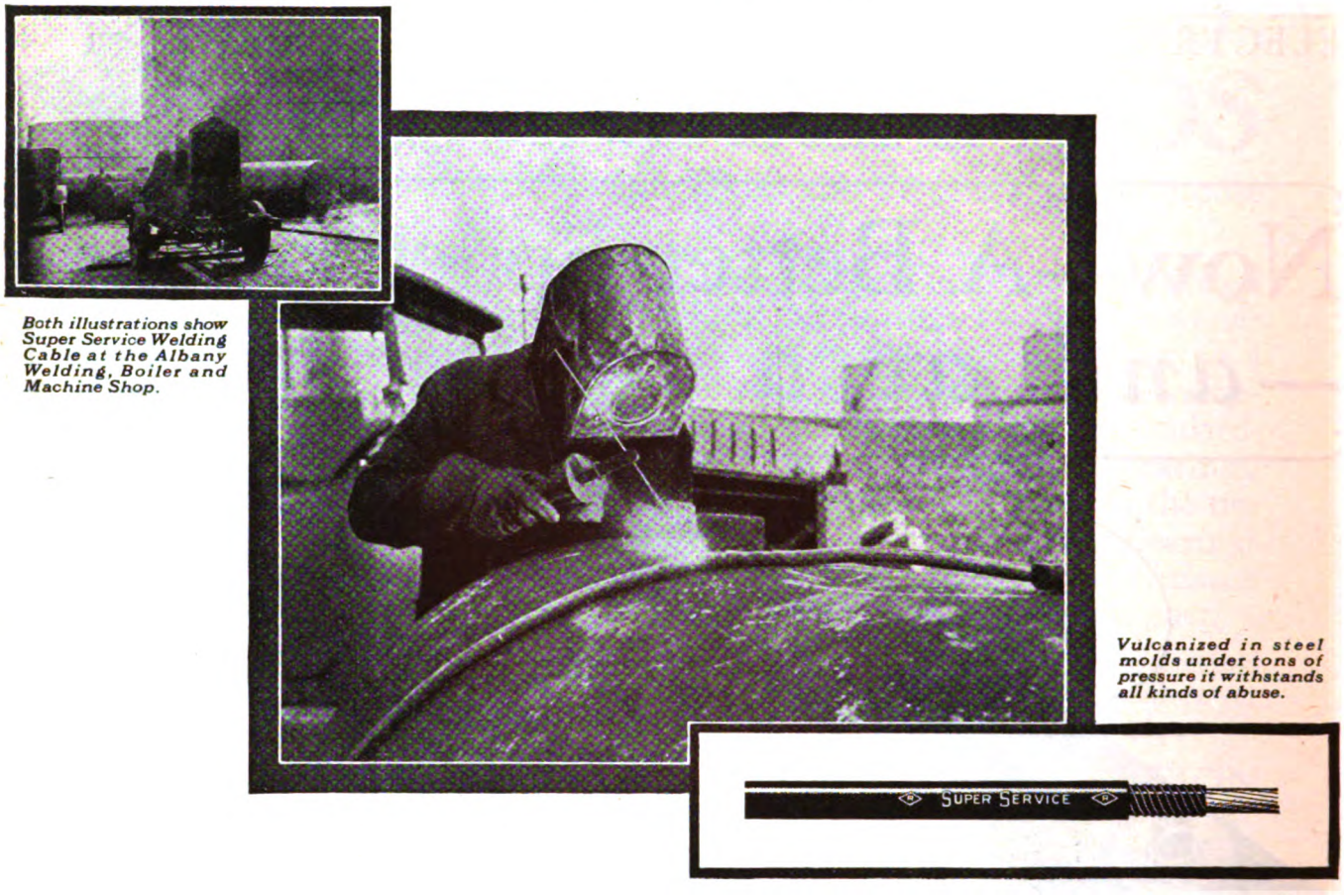
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Northern Electric Co., Ltd., Canada

CUTLER-HAMMER

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Both illustrations show Super Service Welding Cable at the Albany Welding, Boiler and Machine Shop.

Vulcanized in steel molds under tons of pressure it withstands all kinds of abuse.

"Far Superior to other types of rubber sheathed cables"

"WE have used it on all manner of jobs such as welding steel tanks, steamboat boilers, and various emergency jobs. I am pleased to say that today the cable is in perfect condition, and apparently good for some years to come.

"The braided cables which we formerly used are not to be compared with your special Super Service Welding Cable, and we also find this product far superior to other types of rubber sheathed cables which we have used."

This statement is taken from a letter from Mr. Ray Gaul, president of the Albany Welding, Boiler and Machine Shop, after his Super Service Welding Cable had been in use for three years.

You can't beat Super Service for wear, and its extreme flexibility eliminates the need for splicing on a separate length of wire for the electrode holder.

If you have never used Super Service get a length today and try it out.

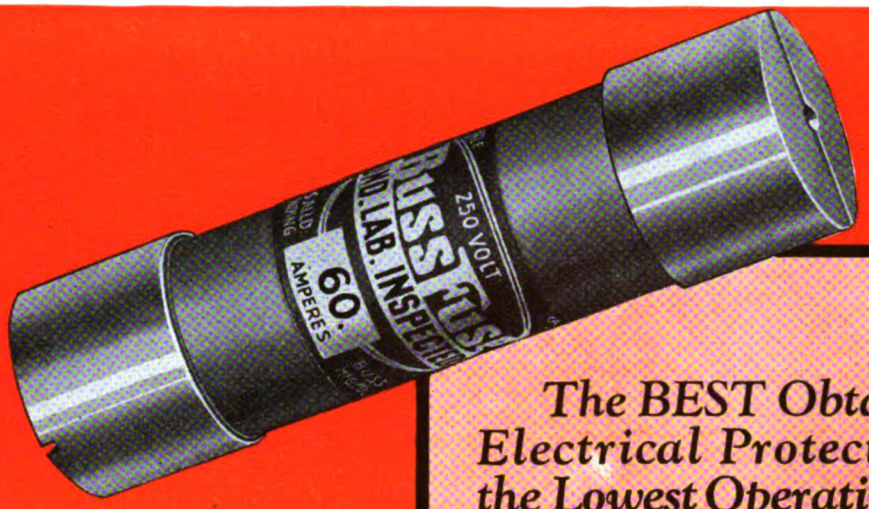
ROME WIRE COMPANY
Mills and Executive Offices: Rome, N. Y.
Diamond Branch: Buffalo, N. Y.
New York—50 Church Street *Boston*—Little Building *Chicago*—14 E. Jackson Blvd.
Detroit—25 Parsons Street *Cleveland*—1200 West 9th Street
Los Angeles—J. G. Pomeroy, Inc., 336 Azusa Street
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SUPER SERVICE CORDS and CABLES

2542

A ROME WIRE PRODUCT

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The BEST Obtainable Electrical Protection at the Lowest Operating Cost

The Underwriters label of approval and the confirmation of thousands and thousands of actual fuse users through all of North America are your warranty of Electrical Protection.

The few parts and the simplicity of their design make ease and speed of renewal instantly apparent. That same simplicity of design insures long life.

Note the cap used on the ferrule contact type BUSS Renewable Fuse.

It is full length. Perfect contact with the clips is thereby assured. No chance for varying diameters of the contact parts.

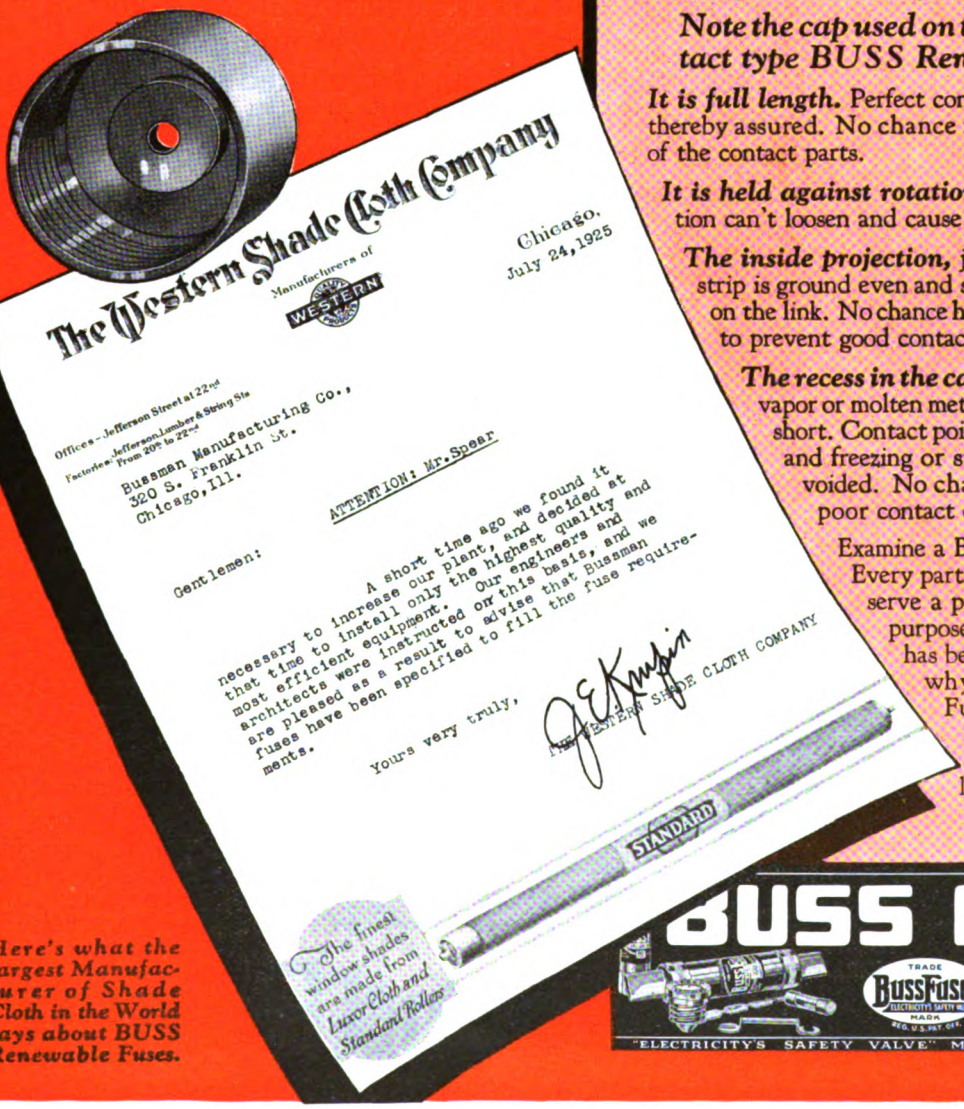
It is held against rotation by the clips. Vibration can't loosen and cause poor contact.

The inside projection, just the width of the strip is ground even and smooth. It bears only on the link. No chance here for foreign matter to prevent good contact.

The recess in the cap takes up all metallic vapor or molten metal expelled on a heavy short. Contact points are thus protected and freezing or sticking of the caps avoided. No chance here either for poor contact on the next renewal.

Examine a BUSS renewable fuse. Every part has been designed to serve a particular and useful purpose. Every useless part has been eliminated. That's why BUSS Renewable Fuses give the best obtainable Electrical Protection at the lowest operating cost.

Send for a Sample



The Western Shade Cloth Company

Manufacturers of WESTERN

Chicago, July 24, 1925

Offices - Jefferson Street at 22nd
Factories: Jefferson, Lumber & String Sts. From 20th to 22nd

Busman Manufacturing Co.,
320 S. Franklin St.
Chicago, Ill.

ATTENTION: Mr. Spear

Gentlemen:

A short time ago we found it necessary to increase our plant, and decided at that time to install only the highest quality and most efficient equipment. Our engineers and architects were instructed on this basis, and we are pleased as a result to advise that Busman fuses have been specified to fill the fuse requirements.

Yours very truly,

WESTERN SHADE CLOTH COMPANY

STANDARD

The finest window shades are made from Luxor Cloth and Standard Rollers

Here's what the largest Manufacturer of Shade Cloth in the World says about BUSS Renewable Fuses.

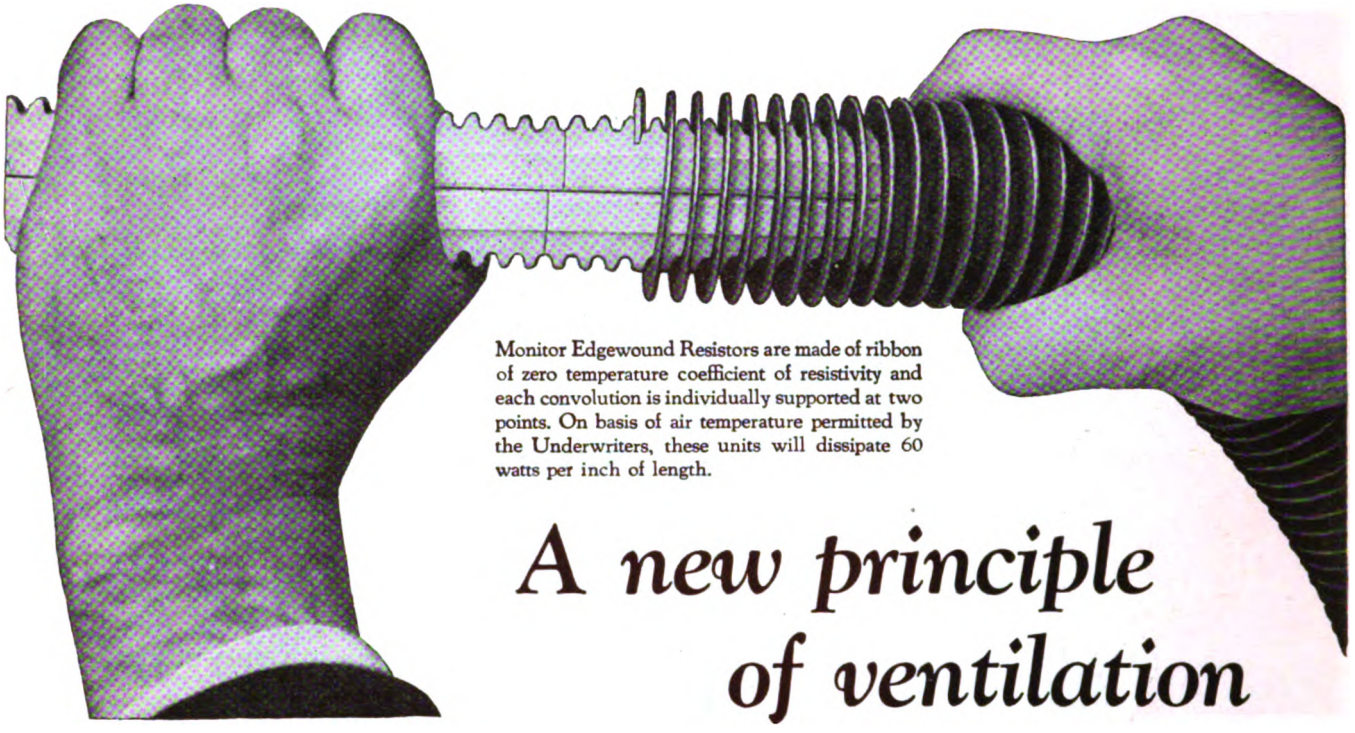
BUSS FUSES

TRADE BUSS FUSES ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

APPROVED IN ALL TYPES AND SIZES

"ELECTRICITY'S SAFETY VALVE" MEANS ONLY BUSS FUSES

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Monitor Edgewound Resistors are made of ribbon of zero temperature coefficient of resistivity and each convolution is individually supported at two points. On basis of air temperature permitted by the Underwriters, these units will dissipate 60 watts per inch of length.

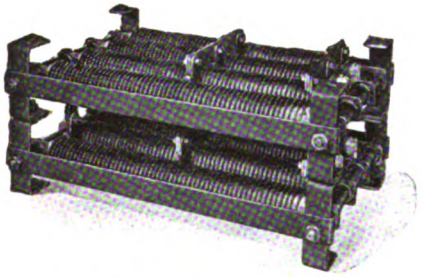
A new principle of ventilation

HEAT is dissipated from Monitor Edgewound Resistors so evenly and uniformly that the temperature of the resistive conductor is, for all practical purposes, the same throughout.

The resistor units can be mounted side by side, on end, or on top of each other without affecting the even dissipation of heat and without overheating any part of the resistor as a whole. As a result there is no danger of a Monitor Edgewound Resistor burning out due to overheating in any section.

This unusual performance of the Monitor Edgewound Resistor is due to a new principle of ventilation plus the absence of localized heating such as occurs in resistors that change resistance with temperature. The well known "chimney effect" which causes cumulative heating, often burning out those parts in the path of the upwardly moving heated air, is eliminated.

Stronger, more compact, lighter in weight and more flexible and simple in its arrangement and construction than any resistor ever known, the Monitor Edgewound Resistor, is worthy of careful investigation. Write for Bulletin 107.



Monitor Eight-unit Edgewound Resistor with four units in parallel and two in series. Resistor tapped at two intermediate points.

The Original "Just Press a Button" System

Monitor Controller Company

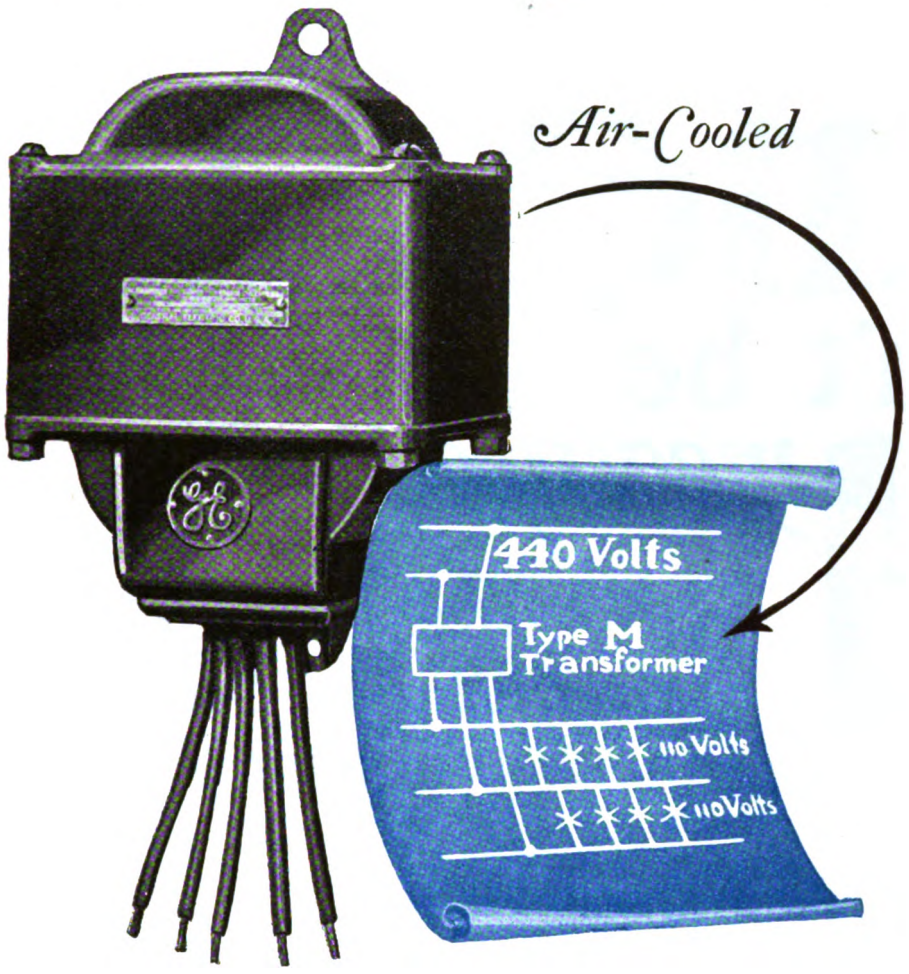
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Birmingham Boston Buffalo Chicago Cincinnati Cleveland
New Orleans Detroit St. Louis Pittsburgh New York Philadelphia

6720-2

Monitor Edgewound Resistor

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110-Volt standard lamps *on* 440-Volt power circuits

Nominal 110-volt circuits can be obtained from 220-volt, 440-volt, or 550-volt sources of supply by installing a Type M Transformer. This enables the use of standard lamps and equipment without putting in a special circuit.

Sizes of these transformers are 15 to 5000 watts, 60 cycles, and up to 3000 watts, 25 cycles, all 600 volts and below.

The outstanding characteristic of Type M Transformers is that they are ***air-cooled,*** utilizing no oil in their construction. This makes them ideal for indoor use. Bulletin 65105 gives all details as to ratings and dimensions. Ask for a copy.

Type M Transformers are admirably adapted to many other low-voltage needs including 3-phase to 2-phase transformations.

They are ideal for ***special*** low-voltage requirements as well, because "specials" can readily be built from standardized "M" parts.

They are attractive in appearance, and their construction is such that they may be mounted indoors or outdoors as desired. They can also be furnished for conduit wiring installations.

Tell the nearest G-E Office what you wish to accomplish.

17F-2

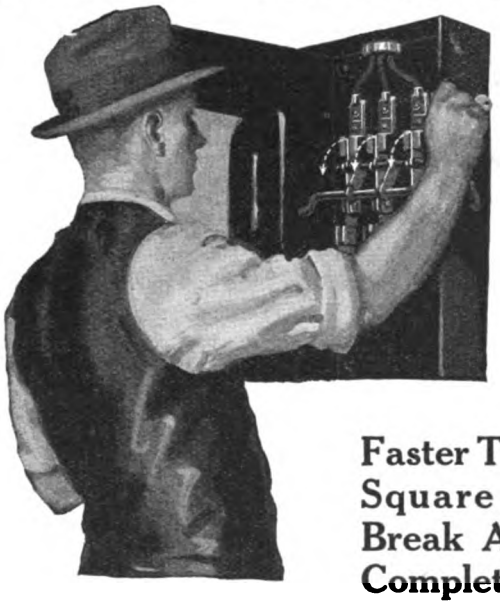
GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL LARGE CITIES

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Time that can't be measured!





.... the instant when the blades snap home!

Faster Than the Eye can Follow, the Square D Quick-Make, Quick-Break Action Throws the Switch Completely *On* or Completely *Off*.

In Square D you have the advantage of the simplest and most efficient design to accomplish positive quick make and break. Square D blades snap solidly home with clean, instant, perfect contact at all points—and disengage just as quickly. The switch is *on* or *off* with a minimum of arcing.

Added to this important feature there are many other outstanding Square D advantages—individual base construction that makes part replacements quick and simple; key controlled accessibility and safety; dust proof and dirt proof enclosure for long life and trouble-free service.

Such efficiency, such sturdiness, such quality, have built Square D's unquestioned leadership—leadership based on three million successful installations.

We invite your personal inspection of Square D. Ask your jobber or write us direct.

SQUARE D COMPANY, DETROIT, U.S.A.
FACTORIES AT: DETROIT, MICH., PERU, IND. (71)
BRANCH OFFICES: Boston, Buffalo, Chicago, New York, Pittsburgh, St Louis, Philadelphia, Cincinnati, Milwaukee, Atlanta, Cleveland, San Francisco, Los Angeles, Syracuse, Kansas City, New Orleans, Baltimore, Columbus, Minneapolis, Indianapolis.
SQUARE D COMPANY, CANADA, LTD., WALKERVILLE, ONT
BRANCH OFFICES: Toronto, Montreal



SQUARE D
Safety Switch

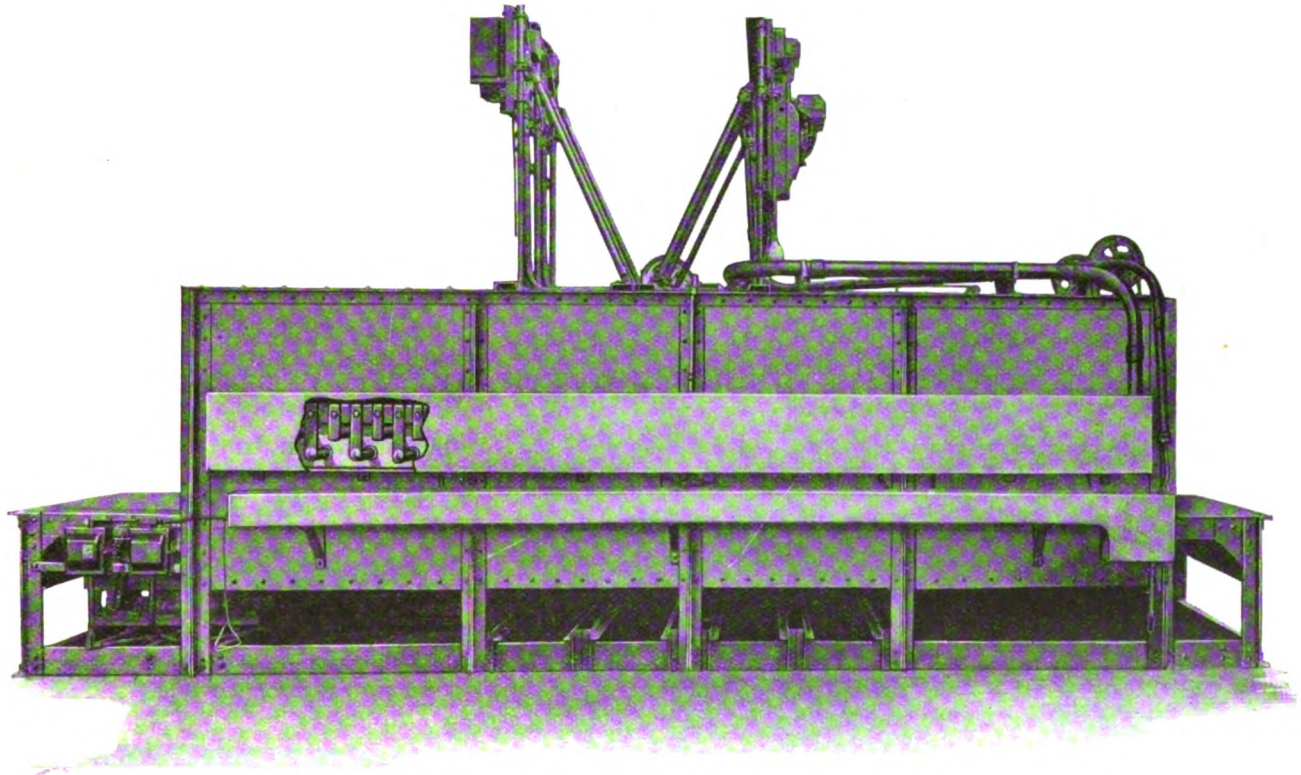
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Globar

NON METALLIC **ELECTRIC HEATING ELEMENT** CARTRIDGE TYPE

Globar Heating Elements are particularly adaptable for Industrial applications by virtue of their high operating temperatures. They operate successfully at any temperature up to 2750 degrees F, (1500 degrees C). Globar Elements are increasing efficiency in production — effect a new economy — permit of accurate temperature control and solve element mounting troubles. Let our Engineering and Development Laboratory help you with your present furnace problems.

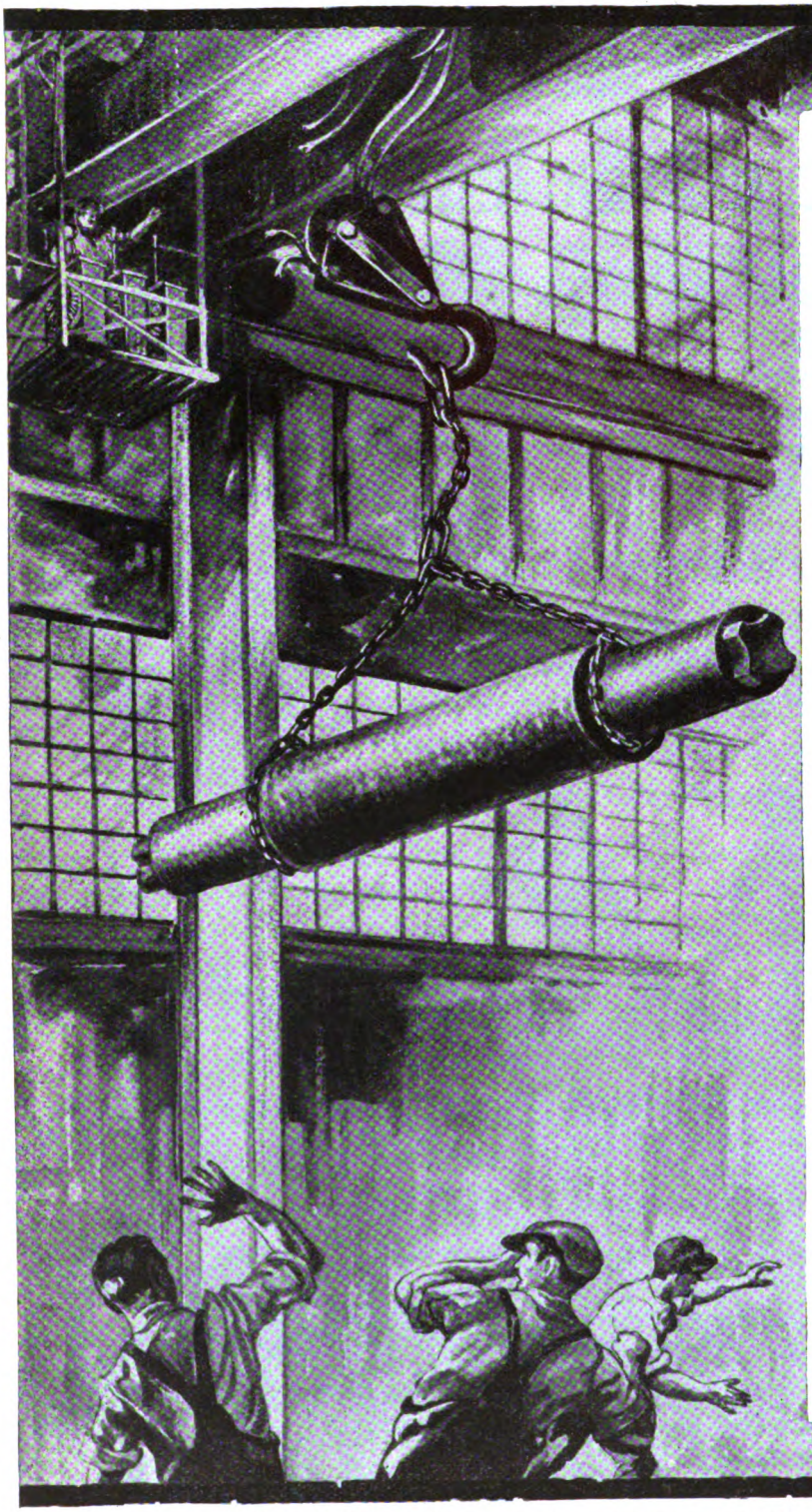
American Resistor Company
Milwaukee
New York—Philadelphia—San Francisco—Los Angeles



THE ELEMENT OF ECONOMY

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-and no Youngstown Limit Stop



A moment of carelessness—the operator fails to realize that the hook is too high—unnoticed, it travels beyond the point of safety—**AND NO YOUNGSTOWN LIMIT STOP—**

The operator throws his controller to reverse—but too late—too late for the safety of the men on the floor below—hoisting ropes snap—the heavy bottom block and load drop—

Had you ever thought that such an accident can easily happen in your plant if your cranes are not properly protected against over-hoisting?

EC&M Youngstown Safety Limit Stops make accidents of this kind impossible. They have never been known to fail in their operation.

Send for Bulletin 1040-B

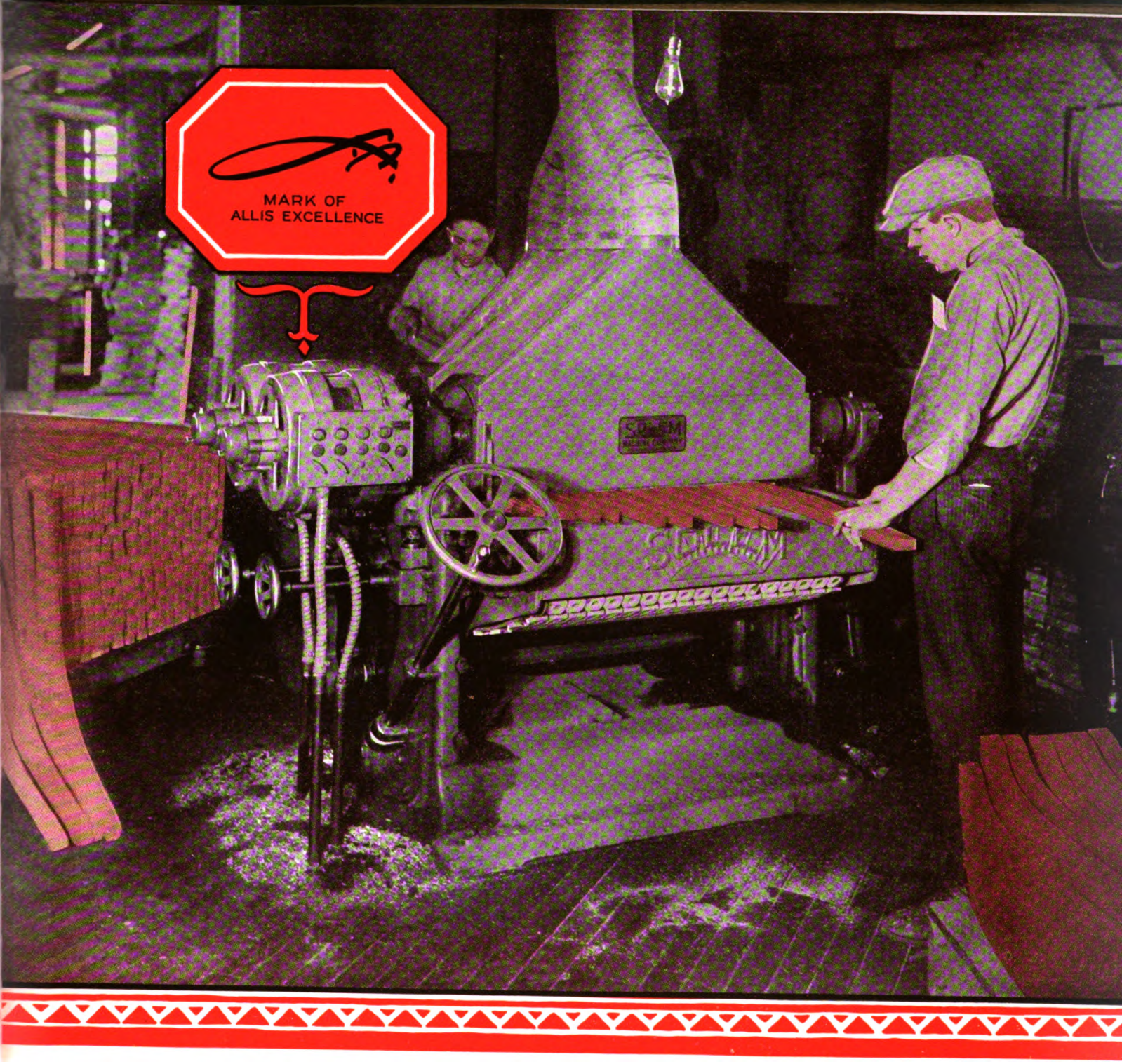
THE ELECTRIC CONTROLLER & MFG. CO.

BIRMINGHAM-BROWN-MARX BLDG.
CHICAGO-CONWAY BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
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SEATTLE-570 COLMAN BLDG.
TORONTO-TRADERS BANK BLDG.

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Motors Built for the Job

DESIGNED by the Louis Allis Company, a motor becomes an integral part of the machine to which it is applied. Electrically and mechanically right, it assures the consistent efficiency of any equipment. That is why you will find L-A motors so frequently "built-in."

An engineering department, skilled in meeting difficult requirements, and a production department in giving unusual service, are at your command.

THE LOUIS ALLIS CO.

Milwaukee, Wisconsin.

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Immediate Service on Louis Allis Motors!

The red dots—each representing a Louis Allis sales office or service connection—tell the story.

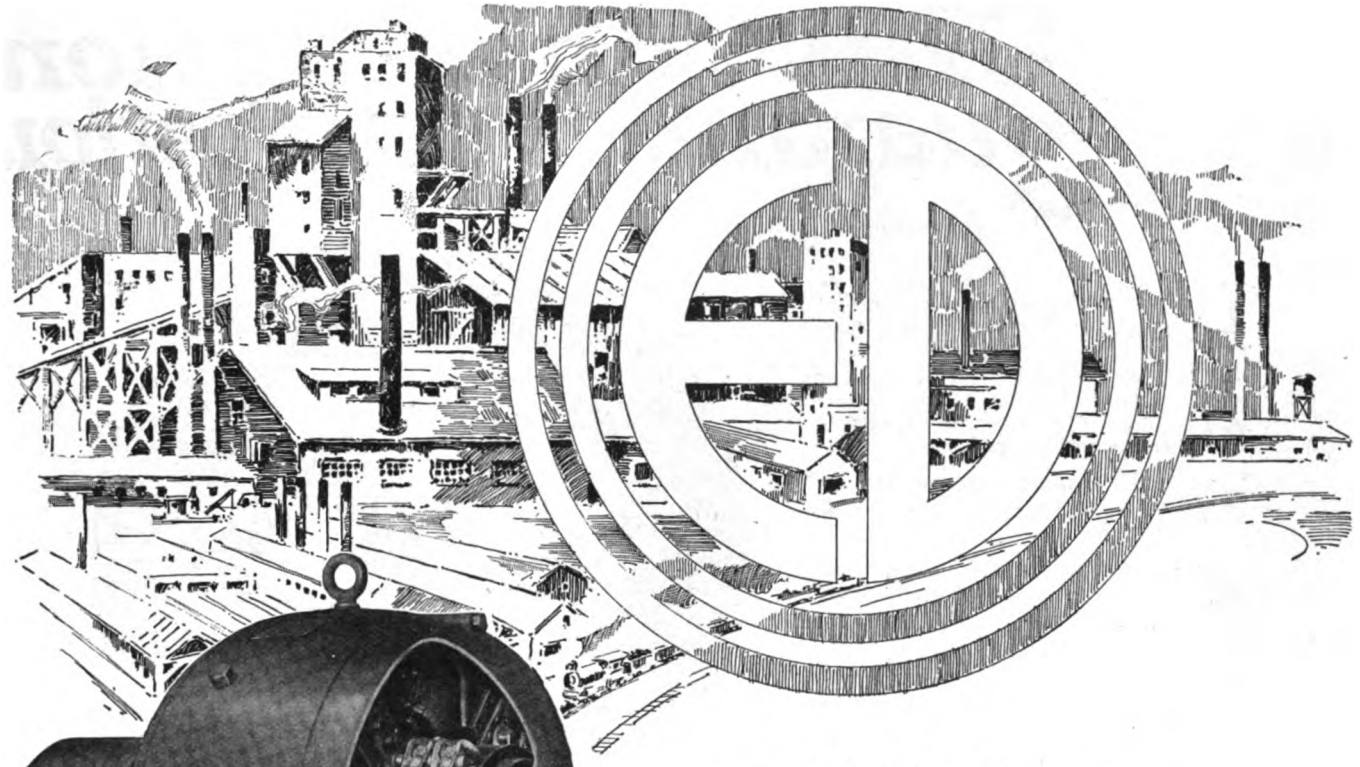
Manufacturers, whose machines are L-A motored, are assured of prompt service at any point in the United States. A service for our customers—and their customers.

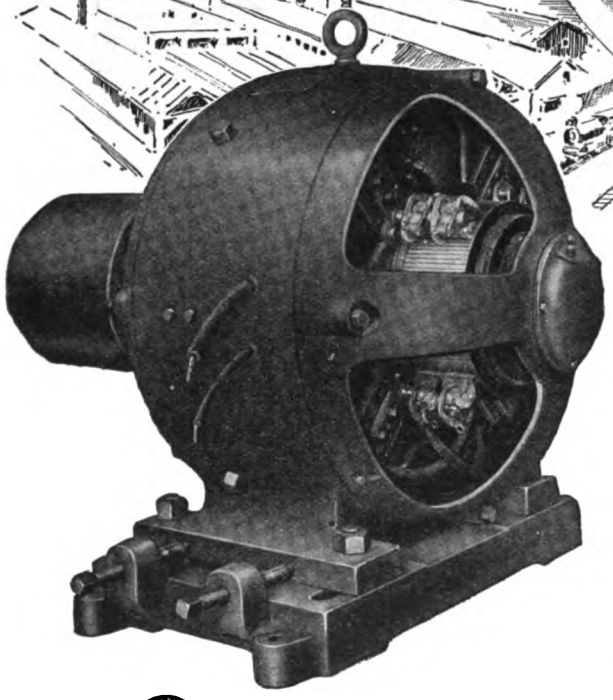
THE LOUIS ALLIS COMPANY, Milwaukee, Wisconsin

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The first ball bearing motor

-Electro Dynamic Motors-

All industry reflects E.D. performance

Everywhere in industry you can find Electro Dynamic Motors cutting power costs. For they maintain a day-in-and-day-out service that reduces to a minimum time and money spent on repair and maintenance. Years of hard service have proved their ability to stand the gaff of constant usage.

But such performance can be traced back to E.D. design. For E.D. was the pioneer ball bearing motor and it has maintained such progressiveness of design at all times. So that today it stands in the forefront of motor lines for all industry.

Whatever your motor problems may be, our Engineering Department will gladly work with you in selecting a standard type or suggesting a special type of E.D. Motor to fulfill your requirements.

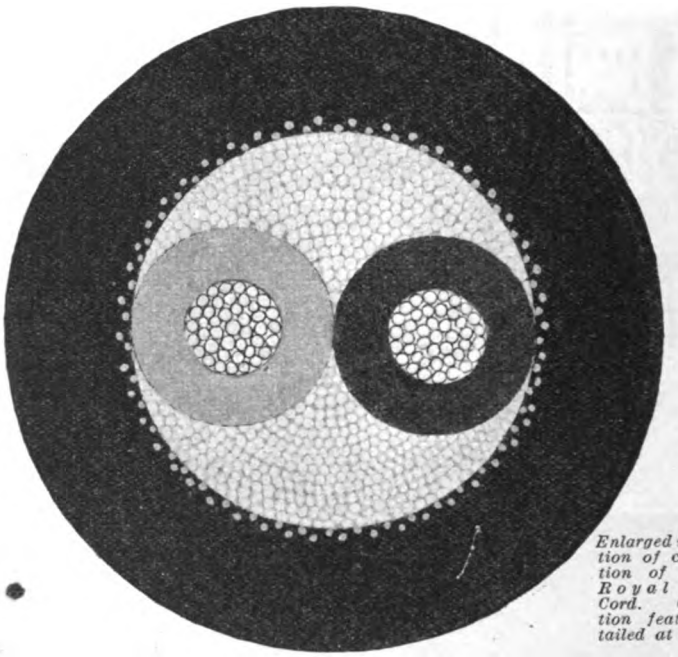
Send for our bulletins to get further particulars

ELECTRO DYNAMIC CO.
BAYONNE, N. J.

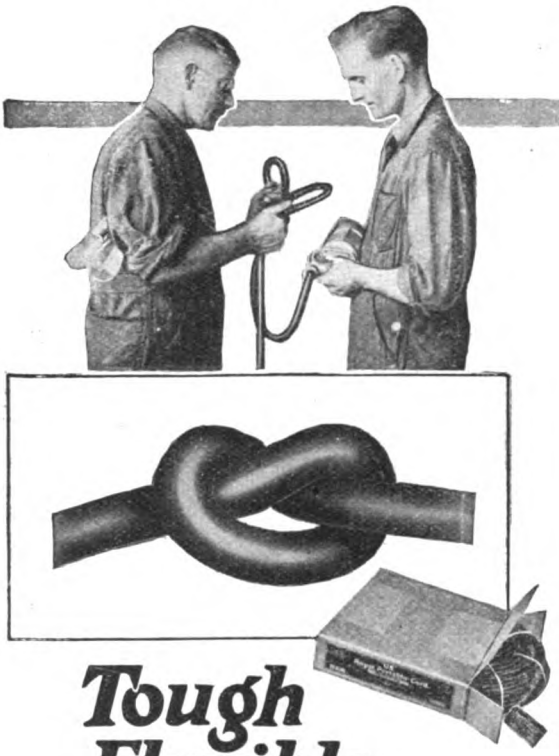
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This construction -guarantees satisfaction

1. The conductors are made up of very fine strands of highest quality copper wire, accurately drawn to size.
2. They are insulated, over a cotton wind, with a wall of 30% rubber. The polarity is indicated by different colored compounds.
3. The conductors are twisted together with a strong filler of long staple cotton.
4. Conductors and filler are encased in a network of heavy silk finish thread.
5. The outer cover is a jacket of special "U. S." Royal Cord compound of the highest grade gum rubber, uniform in diameter, and forced into form under pressure in specially designed machines.



Enlarged reproduction of cross section of "U. S." Royal Portable Cord. Construction features detailed at the left.



"U. S." Royal Portable Cord will stand up under an unparalleled amount of punishment. The construction features shown in the above cross section indicate the story behind "U. S." Royal's dependability.

"U. S." Royal Portable Cord is built to give longer service under even the most severe industrial conditions. The rubber cover is compounded to resist the attack of corrosive elements and extreme abrasion. The interior construction of Royal Cord insures against any possible injury from pulls, jerks, twisting and turning and provides for extreme flexibility.

Years of experience in research and development work and a thorough knowledge of working conditions by the United States Rubber Company have developed this unequalled Portable Cord. The experience of thousands of users has taught them to always specify "U. S." Royal Portable Cord. They have learned that there is no other cord that assures them such long and uninterrupted service from their portable electric equipment.

Send for a Sample to Test for Yourself

United States Rubber Company
1790 Broadway, New York City

Complete Stocks Carried in the Following Cities:

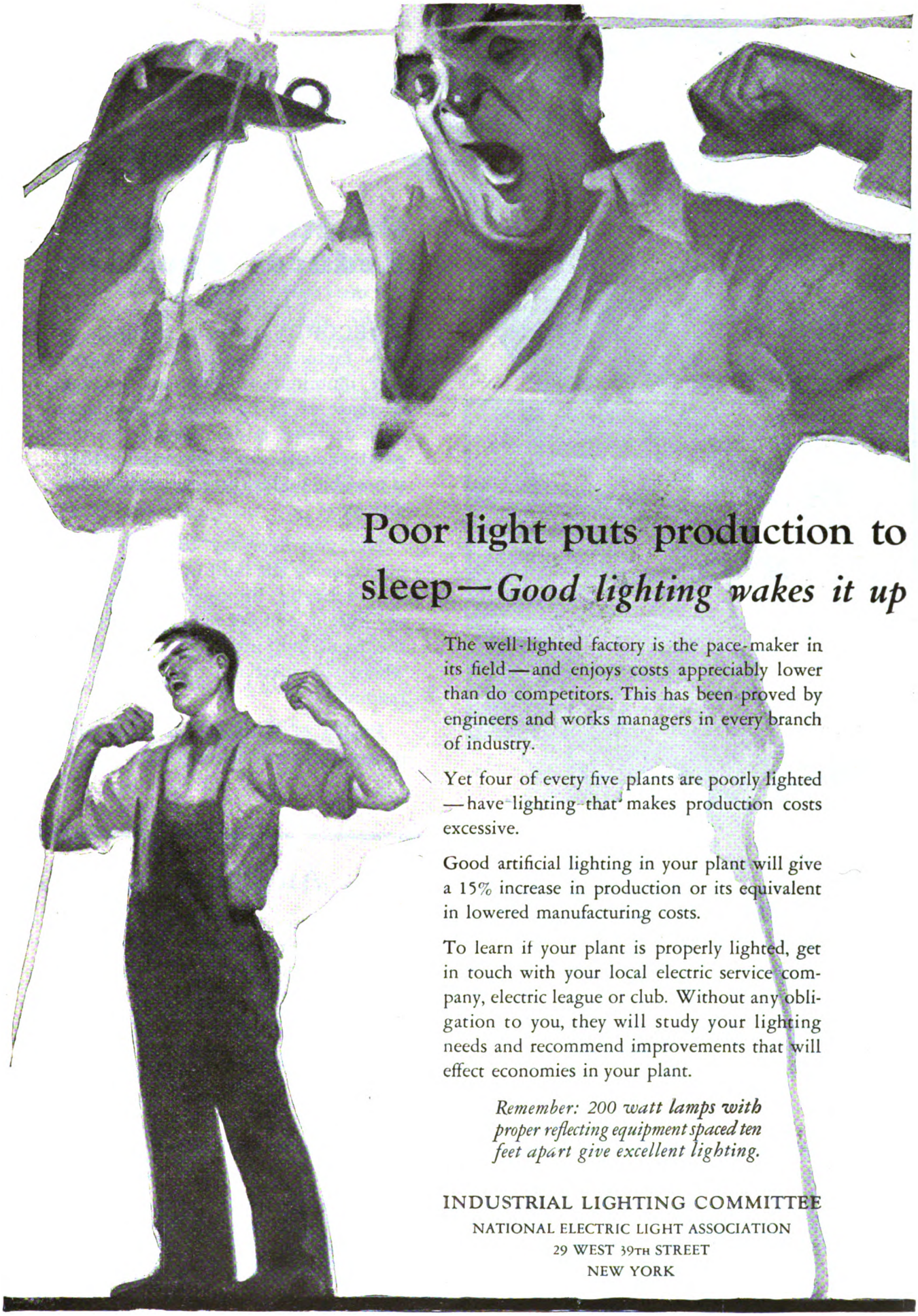
Atlanta	Columbus	New Orleans	Salt Lake City
Baltimore	Denver	New York	San Francisco
Birmingham	Detroit	Omaha	Seattle
Boston	Houston	Philadelphia	Spokane
Buffalo	Indianapolis	Pittsburgh	St. Louis
Chicago	Kansas City	Portland, Ore.	Syracuse
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Cleveland			

Tough Flexible Waterproof

Trade US Mark

"U.S." Royal Portable Cord

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Poor light puts production to sleep—*Good lighting wakes it up*

The well-lighted factory is the pace-maker in its field—and enjoys costs appreciably lower than do competitors. This has been proved by engineers and works managers in every branch of industry.

Yet four of every five plants are poorly lighted—have lighting that makes production costs excessive.

Good artificial lighting in your plant will give a 15% increase in production or its equivalent in lowered manufacturing costs.

To learn if your plant is properly lighted, get in touch with your local electric service company, electric league or club. Without any obligation to you, they will study your lighting needs and recommend improvements that will effect economies in your plant.

Remember: 200 watt lamps with proper reflecting equipment spaced ten feet apart give excellent lighting.

INDUSTRIAL LIGHTING COMMITTEE
NATIONAL ELECTRIC LIGHT ASSOCIATION
29 WEST 39TH STREET
NEW YORK

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W
WESTINGHOUSE ELECTRIC

Good Illumination

Greater Accuracy Reduces Spoilage

(Talk No. 3)

RECORDS made in hundreds of factories that have put in correct illumination show an average decrease of 25 per cent in spoilage. This decrease is due, largely, to the greater accuracy of workmanship that is possible under correct lighting conditions.

Did you ever try to read a micrometer by the light of a candle? It is practically impossible to do so accurately, and yet in many factories the actual light intensity is no greater where the mechanic must take his reading.

Plenty of illumination is equally necessary in any factory where man-

An Illumination Survey

Without cost and without obligation, the Westinghouse Illuminating Engineering Bureau will make a complete survey of your plant. It will then make an unbiased recommendation, telling the present condition of your illumination and how your lighting system could be changed to give an illumination that will pay dividends.

Westinghouse

X85525

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Pays Dividends

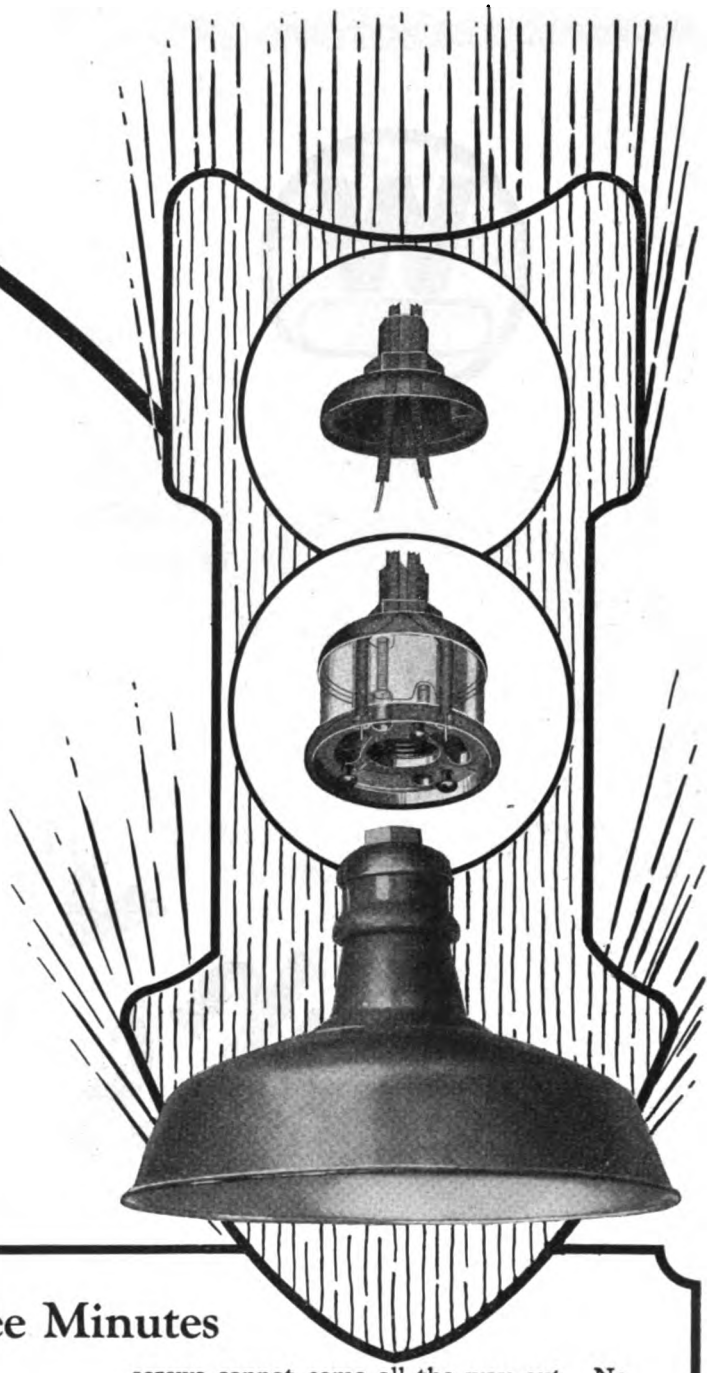
ufacturing operations require close vision.

Lighting conditions other than low intensity may cause spoilage. Glare, shadows, and light from improper directions all cause eye-strain and discomfort. Inaccuracy, with the consequent spoilage, is sure to follow.

All these facts show the necessity for expert knowledge in problems of industrial illumination. Our Illuminating Engineering Bureau places such knowledge at your disposal.

It may be that our Bureau could show you a way to reduce ***your*** spoilage. The advice will cost you nothing and will obligate you in no way.

Westinghouse Electric & Manufacturing Company
Merchandising Department South Bend, Indiana
Sales Offices in All Principal Cities of
the United States and Foreign Countries



Completely Wired in Three Minutes

The Reflector-Socket-Fixture has but three parts. A speed test will prove beyond question its "Easy-to-Wire" claim. Any electrician can completely wire and install the fixture in three minutes.

But three simple operations are necessary.

(1) The cast iron cap is screwed directly onto the conduit.

(2) The wires are drawn through holes in the one-piece porcelain socket. The socket is fastened to the cap with two screws. These screws cannot come all the way out. No loose screws are present to cause fumbling. The operation is completed by clamping the wires under contact screws.

(3) The Reflector is fastened to the socket by three screws. Bayonet slots in the reflector's heel reduce the operation to a slight twist of the reflector and a few turns of the screws.

Reflector-Socket-Fixtures are rigid, weather-proof, and extremely serviceable.

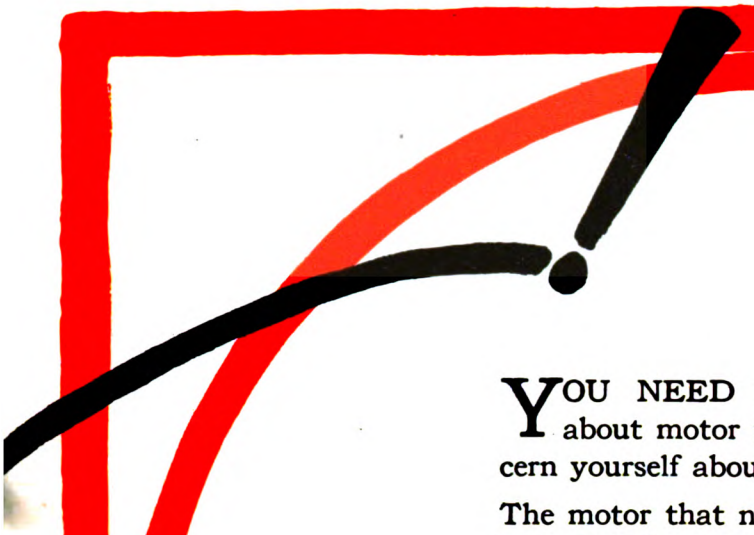
Holder-Socket Reflectors are "Easy to Wire"

Westinghouse

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YOU NEED NOT concern yourself about motor failures, if you first concern yourself about the motor.

The motor that never suffers from hidden hot spots is properly designed, as well as properly constructed. Westinghouse construction is better demonstrated by performance than by description.

Radiating surfaces, fan effect, spacing of properly constructed field coils, ducts under the commutator—each of these has its proper value in Westinghouse design.

Thus ventilation is one of the factors that brings about the highly developed *balance* of all electrical and mechanical characteristics in all of the 22,000 standard types and sizes of Westinghouse motors.

You need never be in doubt about motor performance after you consult Westinghouse.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries



Westinghouse Motors *are balanced!*

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SHARON WORKS
Sharon, Pa.

The Westinghouse Transformer Plant



When An Emergency Demands Prompt Shipment

The distribution transformer is the connecting link between the power station and the equipment using electric power. Prompt shipment of these transformers is frequently a vital factor in supplying service for new equipment.

The new 42-acre transformer factory at Sharon, Pa., with its unexcelled manufacturing and testing facilities, enables Westinghouse to meet promptly these calls for rush shipment of distribution transformers.

The next time you need some transformers in a hurry, let our Sharon Works supply them.

Westinghouse Electric & Manufacturing Company
Sharon Works Sharon, Pa.
Sales Offices in All Principal Cities of
the United States and Foreign Countries

W
WESTINGHOUSE ELECTRIC

Westinghouse

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MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES

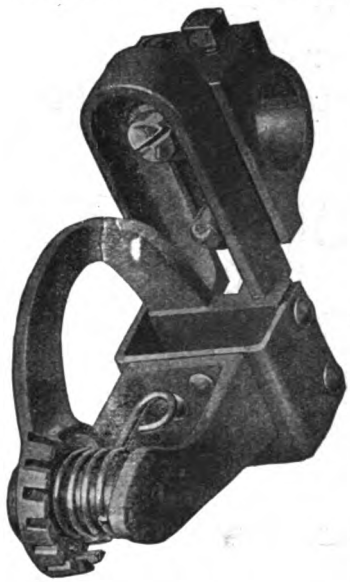


In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that can be done and the dollar-savings that are possible depend on
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.

Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.



FIGURE IT OUT



Flower Brush Holders are designed and built by brush holder specialists to meet the needs of a specific job. They're simple — they're rugged—and they're made only from the finest virgin metals. Naturally they last longer, are more reliable, and practically eliminate "flashover" risks.

Quotations gladly given on any type.

FLOWER
BRUSH HOLDERS

D. B. FLOWER
1217 Spring Garden Street, Philadelphia

Manufacturers of Brush Holders for Motors, Rotary Converters, Generators and Dynamos

"JIFFY" CUTTER

cuts clean round holes quickly and easily, thru steel boxes and switchboard panels.

Saves time and money on every job.

Adjustable Diameters ¾ in. to 6 in. Weighs only 3½ pounds.

Write today for a copy of
"THE HOLE STORY"
It tells the whole story

PAUL W. KOCH & COMPANY
23 So. Wells St., CHICAGO





Miller

Composition Mallets

"Much pleased with its durability."

"Your composition mallet has been in use two weeks steadily. One week it was used on No. 14 galvanized, another week on No. 24 Black Iron. Mechanics are very much pleased with its durability. It is still going strong."

(From an unsolicited testimonial)

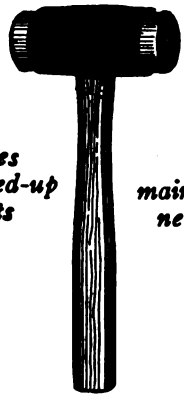
Users usually get fifteen times the service as with an ordinary wood mallet.

Write for Prices

The Miller Rubber Co.
of N. Y.
Akron Ohio

A Hard Blow Without Injury!

"Chicago Rawhide"
Mallets & Rawhide-faced Hammers



Saves battered-up parts

A maintenance necessity

Will transmit an effective blow without damage to the most delicate surface.

But the blow is not more destructive to the tool itself than to the object to which it is applied—therefore, doubly economical.

The Products of our manufacture include:

Belting—Lace Leather—Belt Lacing

Hydraulic Cups and Packing—Mabb's Rawhide Packing — Rawhide Gears — Leather Straps — Washers — Gaskets—Leather Specialties for all purposes

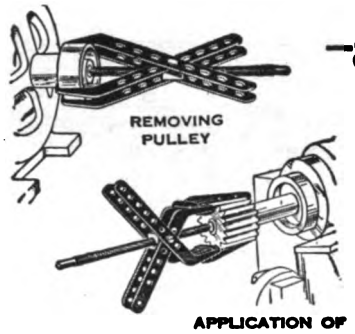
The Chicago Rawhide Mfg. Co.
1279 Elston Ave. Chicago, Ill., U. S. A.

At Your Service—

A service wherein the man who is seeking a position or the man who is desirous of obtaining trained men; where information can be found concerning either the purchase or disposal of used equipment. The purpose of the *SEARCHLIGHT* section of *Industrial Engineer* is to render this service. It simply remains for industrial men to apply this service to their needs.

For Every Business Want—Think *Searchlight* First

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APPLICATION OF EXTENSION ARMS

—a few turns and OFF!

Any pulling job, in any plant or repair shop, is a matter of minutes if LITTLE GIANT or BIG BUSTER is at hand. Small pulleys, gears, flywheels, bearings, etc.—anything up to thirteen inches—will come off for LITTLE GIANT. For heavier work, such as truck wheels or big drive and flywheels, BIG BUSTER will do the trick. LITTLE GIANT and BIG BUSTER are the only pullers operating on the patented principle—"The Harder the Pull the Tighter the Grip"—arms cannot spread and slip off work. Adjustable to varying lengths for uneven pulls—an exclusive feature. Reversible for inside as well as outside pulls.

Price—Little Giant $12.00—Big Buster $50.00.
WRITE FOR ILLUSTRATED FOLDER describing more fully these remarkable tools and the work they do.

Premier Electric Company
1808 Grace Street, Chicago

OHIO ARMORED WEATHERPROOF CONNECTOR



Connect or disconnect instantly (no tools or tape required). Think of the time saved in connecting magnets, welding machines, etc. Made single pole as illustrated, also double or three-pole.

THE OHIO ELECTRIC & CONTROLLER CO.
5910 MAURICE AVENUE ~ ~ CLEVELAND, OHIO.

"CARENCO" BRUSHES



Can't be surpassed for service and efficiency on any type of motor or generator. After a *thorough test*, many of the biggest users have adopted "Carenco" Brushes as *standard equipment.*
Let us send you our new catalog and data sheet. Prove the value of "Carenco" Brushes to yourself!

CARBON-ENGINEERING-CO.
MILWAUKEE, WIS.

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For $2.00 a Year You Can Get One Like it Every Month

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Copper Wire all kinds
Insulating Varnishes
Super-Safety Switches
Electro-Nite Carbons
Commutator Truing Device
Mica Undercutting Tools

ARTHUR B. WEEKS
419 High Ave. Cleveland, Ohio

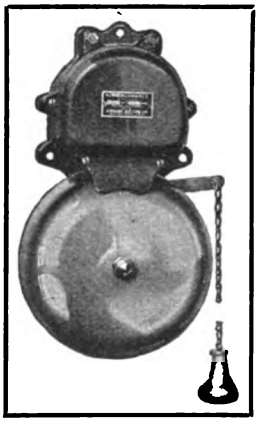
NO Spark Carbon Brushes



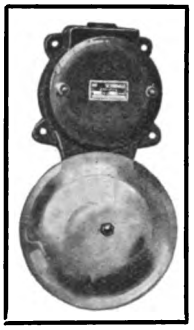
are Self Lubricating. They last longer and serve better than ordinary Brushes. Give them just one trial.

Calebaugh Self-Lubricating Carbon Co.
1503 Columbia Ave.
Philadelphia, Pa.

Weatherproof SCHWARZE Vibrating Bells



With Manual Trip Attachment



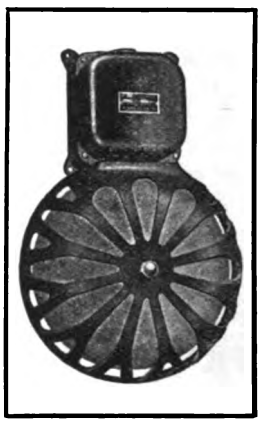
No. 6c D. C. Cyclone
No. 7c A. C. Cyclone



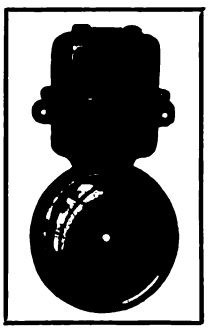
Nos. 76 and 77
A. C. Cyclone Bell



No. 6 D. C. Cyclone
No. 7 A. C. Cyclone



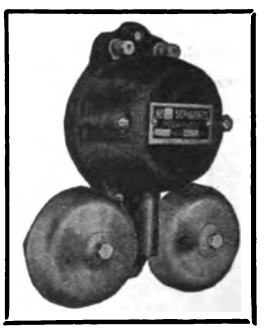
Full Protective Grid



No. 75
A. C. Cyclone

Transformer and High Voltage A. C.
Battery and High Voltage D. C.

Cyclone bells are approved by National Board of Fire Underwriters for Industrial Signalling. They are the most reliable bells for Fire Alarm and General Calls in your plant. Write factory or nearest branch office for catalogue and full particulars.



Nos. 9, 9A and 11
A. C. Polarized

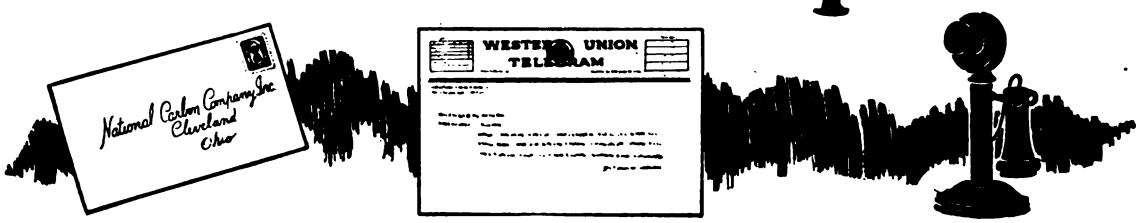
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St. Louis, Mo. 1415 Pine St.

Main Office and Factory
Schwarze Electric Co., Adrian, Mich., U. S. A.

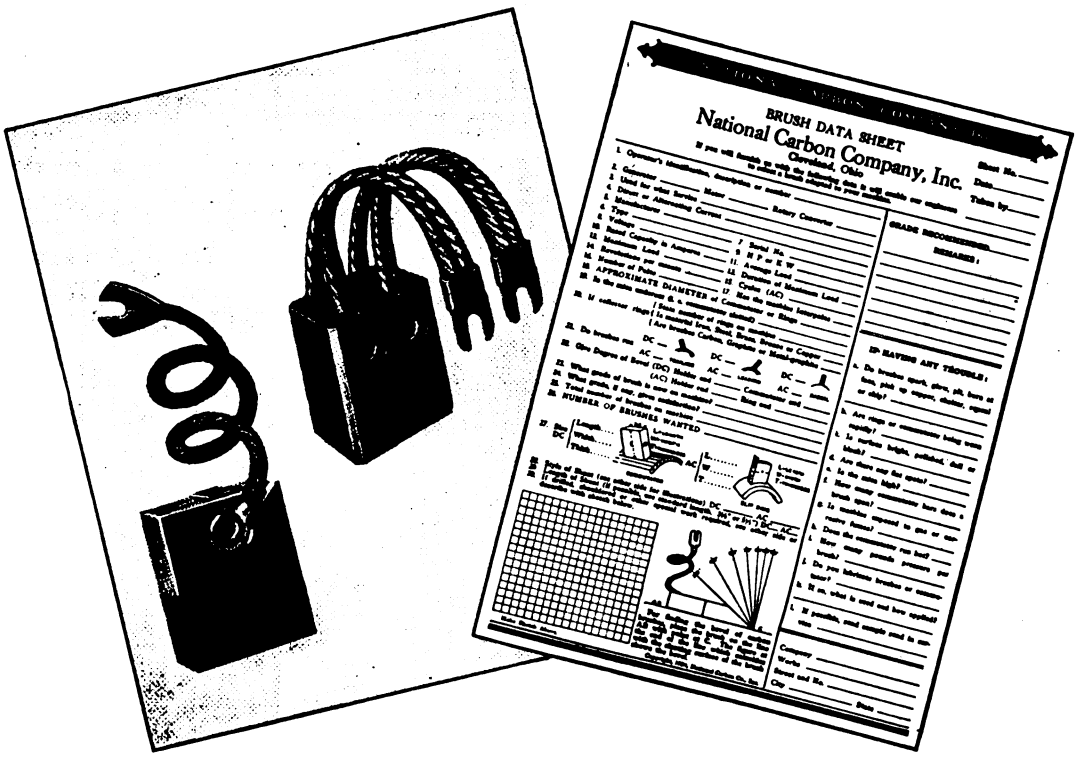
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write – wire – phone



WHEN you need brushes on short notice for any reason *write, wire* or *phone* the nearest of our four plants, and the National Pyramid Brushes you need will be on their way to you immediately.

Have we complete data sheets on your motors, generators and converters? Information regarding our data sheet service gladly sent on request.



The services of our Sales Engineers are always at your disposal

Manufactured and guaranteed by

NATIONAL CARBON COMPANY, INC.

Carbon Sales Division

Cleveland, Ohio San Francisco, Cal.

Canadian National Carbon Co., Limited, Toronto, Ontario

Emergency Service Plants

CHICAGO, ILL.
551 West Monroe St.
Phone: STAte 6092

PITTSBURGH, PA.
Arrott Power Bldg. No. 3
Barker Place
Phone: ATLantic 3570

NEW YORK, N. Y.
357 West 36th St.
Phone: LACkawanna 8153

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"Your armature brush can start or stop a lot of trouble"

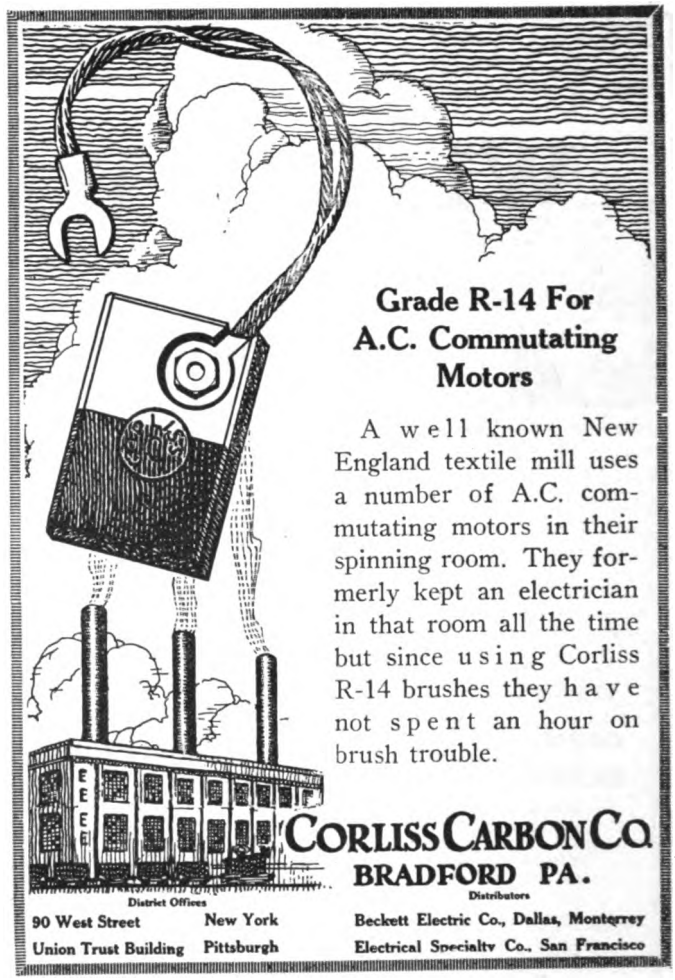
It's a question of the proper brush for your requirements — a question of getting armature brushes with the right abrasiveness, proper co-efficient of friction and correct contact drop for your particular motors.

Among the different types of H & H brushes there is one to fit your exact requirements, that will assure cool operation and perfect commutation with minimum wear.

Let us go into your particular requirements with you.

HOHMAN & HILL, Inc.

1900 Southport Ave., Chicago, Ill.



Grade R-14 For A.C. Commutating Motors

A well known New England textile mill uses a number of A.C. commutating motors in their spinning room. They formerly kept an electrician in that room all the time but since using Corliss R-14 brushes they have not spent an hour on brush trouble.

CORLISS CARBON CO.
BRADFORD PA.

District Offices
90 West Street New York
Union Trust Building Pittsburgh

Distributors
Beckett Electric Co., Dallas, Monterrey
Electrical Specialty Co., San Francisco

Do your **COMMUTATORS** run **HOT?**
Do you have **DESTRUCTIVE SPARKING?**
Are your **BRUSHES** wearing **GROOVES?**
Are your **MACHINES NOISY?**

Eliminate all these troubles and Prolong the Life of Machines

by equipping them with

The original and improved

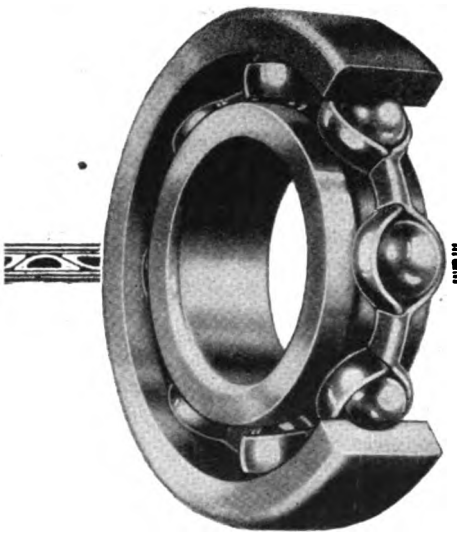
Reaction Brush Holder

over 20 years in service

Let us equip a Generator or Motor for *you.* Make its *final acceptance* subject to your *approval after any reasonable period of operation.*

THE BAYLIS CO.
50 Nelson Street
BLOOMFIELD, N. J.

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Advantages of ball bearings for electric motors

THIS advertisement is the twelfth of a series appearing monthly in this magazine. Previous advertisements have summarized the following advantages of ball bearings for electric motors:

1. *Short overall length of motor*
2. *No shorts from oily windings*
3. *Clean bearings*
4. *Small, constant air gap*
5. *Reduced maintenance costs*
6. *Thrust load capacity*
7. *Repair bills cut*
8. *Smaller stock of spares*
9. *Belted in any position from any direction*
10. *International interchangeability.*
11. *Long life*

XII. Higher Efficiency

Motor friction losses cost money,— power money. And anything that reduces such losses means a real dollars and cents saving in the owner's pocket.

Here is where ball bearing motors show a decided advantage over motors of any other type.

Assume, for example, that a ball bearing motor is only 2% more efficient than a sleeve bearing motor of the same rated capacity,— and this figure is conservative, according to available comparative performance data. Then 30 motors, each delivering 10 H.P. and running 3000 hours a year, would show an annual saving of 30x10x3000x.02=18,000 H.P. hours. At a cost of 2c a horsepower hour this would amount to a yearly saving in power of $360 for the 30 motors.

Note that this is a saving in power only. It does not include the corresponding savings in lubrication, maintenance, and production losses already considered in previous advertisements of this series.

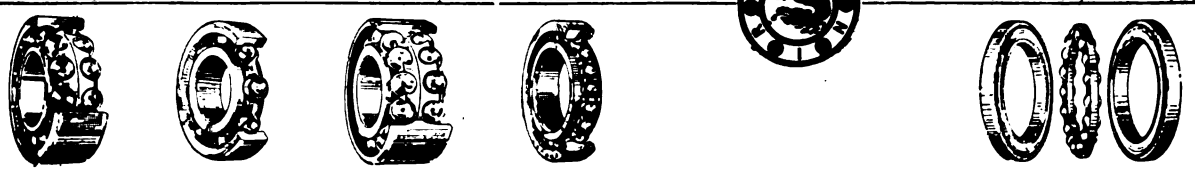
THE FAFNIR BEARING COMPANY

Makers of high grade ball bearings, the most complete line of types and sizes in America

NEW BRITAIN, CONN.

Chicago Newark Cleveland Detroit

FAFNIR
BALL BEARINGS



THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA

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Look into these Continuous-tooth Herringbone IXL Gears

They Have Some BIG Advantages

IXL Herringbone Gears and Speed Reducers are especially adapted for heavy duty drives, high speeds, continuous service, where high efficiency is an important factor and where vibration and noise are objectionable.

Advantages of Continuous Generated Teeth with 30 Degree Helix Angle



1. Greater load carrying capacity.
2. Greater strength of tooth.
3. Greater Bearing surface per tooth.
4. No undercutting of teeth.
5. Extreme quietness of action.
6. Narrower faced gears to transmit same HP.
7. Elimination of Backlash.
8. Minimum vibration.

We make single, double and triple speed reduction units. Capacities up to 150 HP. and Reduction ratios up to 350-to 1.

We Manufacture
Cut Gears of all Kinds
Micarta Pinions
Micarta Timing Gears
Flexible Couplings
Gear Racks
Speed Reducers
Special Machinery

FOOTE BROS. GEAR & MACHINE CO.
236-246 N. Curtis St. Chicago, Ill.
Sales offices in all principal cities in U. S. and Canada.

FOOTE BROS. GEAR & MACHINE CO.
236-246 North Curtis Street
Chicago, Illinois

Established 1905

Please send us full information on IXL Herringbone Gears or Speed Reducers to meet our requirements as per the enclosed specifications. R-128

*Address*_____

*Signed*_____



Announcing—
THE NEW TRICO
GIANT SIZE
FUSE PULLER and REPLACER

The big brother to the standard pocket-size model—a rugged, oversize tool for safely and conveniently handling fuses of large capacity.

For fuses from
100-600 Amps. 250 V.
60-400 Amps. 600 V.

Made with 7 laminations of highest grade genuine horn fibre, tested at 35,000 Volts. A Brute for Size and Strength —just the thing for large installations.

WRITE TODAY for literature and name of nearest dealer.

NOTE: Ask for information on Trico Powder Packed Time Limit Renewable Fuses — "Famous for Their Performance" —the line that reduces blowouts 80 per cent.

Trico Fuse Mfg. Co.
Dept. A
Milwaukee, Wis., U. S. A.

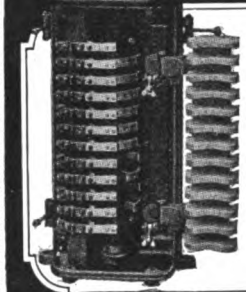
TRICO REG. U. S. PAT. OFF.



GIANT SIZE Length 12 In. Price $3.00 In U. S. A.

POCKET SIZE Length 7½ In. Price $1.00 In U. S. A.

UNION Controllers



Specially designed for
Hoisting Machinery.
Metal and Woodworking equipment.
Electric Trucks and Tractors.
Mine Locomotives.
Pumps, Fans and Blowers.
All General-Purpose Motor Control applications.

Send for bulletins and detailed information.

Union Electric Mfg. Co.
Milwaukee, Wis.
20 Sales and Service Offices

TRANSFORMERS
That's Us!

LARGE OR SMALL. When you are in the market for transformers, get our quotations. *Any voltage—any capacity.* We are in position to give prompt deliveries on quality built transformers.

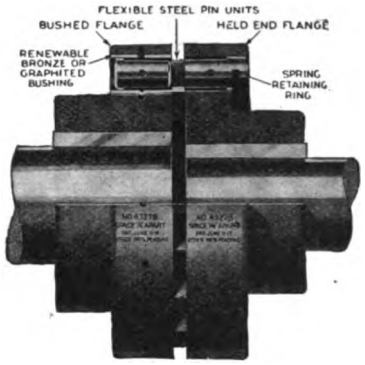
Campbell Mfg. Company
19 Stewart Street Lynn, Mass.

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The New, Improved *Effective Dec. 1, 1925*

FRANCKE
FLEXIBLE COUPLINGS

For Motor, Turbine, Engine Drives



Bushed Pin Type

Graphited bronze bushings in Size No. 850 and larger (bronze bushings in smaller sizes) are removably locked in one flange. The steel pin units are free to slide a full half inch within these bushings. Contact surfaces are more than doubled; a cylindrical surface is obtained; movement is between steel and bronze; and the graphited bushings present a self-lubricated surface that retains its lubricating qualities for many years.

The Improved Francke Coupling retains the best features of the old Heavy Pattern Type and adds several new features to make a better coupling. More and easier endwise movement. Greater power and bore capacities Much longer life for all speeds. Steel flanges for small and intermediate sizes. Lower prices.

The Francke handles all accidental misalignments—Out of center, in an angular direction and endwise; cushions starting and load shocks; absorbs vibrations; runs in either direction; is noiseless.

In case of excessive misalignment it acts as a safety device saving broken or scored shafts, bearing troubles, etc. However, if more than the usual misalignments are expected, due to non-rigid foundations or for any other reason, two couplings in tandem with an intermediate shaft or a Double, Floating-Ring Type Francke Coupling should be used.

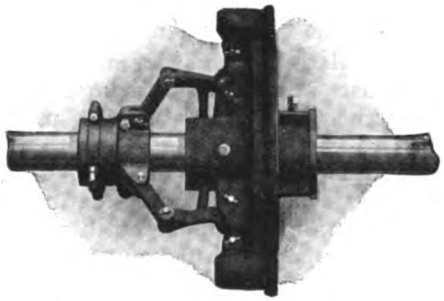
Other Francke Features. Easily mounted, aligned and connected without special tools. All metal, no perishable material. No movement or wear on shaft flanges to cause expensive renewal of complete coupling. Simple and safe.

Ask for Bulletin 37S

SMITH & SERRELL
Coupling Specialists Since 1912

26 Washington Place, Newark, N. J.

WELLER
STEEL PLATE
FRICTION CLUTCHES



NOTE the Absence of Projecting Bolts or Lugs
Also Compact, Solid, General Lines.

WELLER MADE CHICAGO

We make
a Complete Line of
Transmission Machinery
For Belt or Rope Drives
also
Conveying Machinery
Send for Catalogue 35A Transmission Machinery

WELLER MFG. CO.
1820-1856 N. Kostner Avenue **CHICAGO, ILL.**

SALES OFFICES

New York	**Buffalo**	**Baltimore**	**Pittsburgh**
Detroit	**St. Louis**	**Omaha**	**Salt Lake City**

SPEED REDUCING UNITS

Up to 5 H. P. Capacity

Send for Catalog

WINFIELD H. SMITH
116 Eaton Street **Springville, N. Y.**



Torrington **BEARINGS**

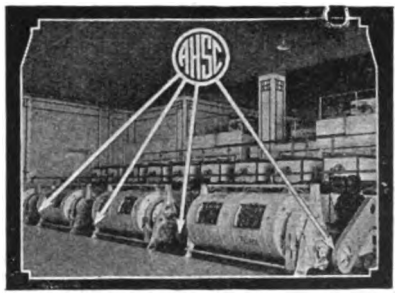
Accurate
Dependable
Quiet
Samples or
Specifications
on request

The Torrington Company
ESTABLISHED 1866
TORRINGTON, CONN., U.S.A.

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Simplicity Plus 98% to 99% Efficiency

American High Speed Chains operating churns in Fox River Creamery Co., Chicago.



Efficiency At Its Highest

No device is more efficient than American High Speed Chain. It is the "ball bearing" of power transmission. It is 98% to 99% efficient.

Your plant needs American High Speed Chain Drives just as machines of high efficiency need ball bearings. They save power, avoid practically all the costly break-downs experienced with other forms of power transmission, and speed up production.

We now have a complete stock of chains and sprockets up to 10 H. P. and 7 to 1 reduction, from which we can ship on less than 48 hours notice. Ask for Catalog No. 105.

If you desire conclusive proof, try American High Speed Chains on some of the drives in your factory. They will sell themselves to you and soon you will have your whole plant equipped with them. Save power!

Write for Our Catalog

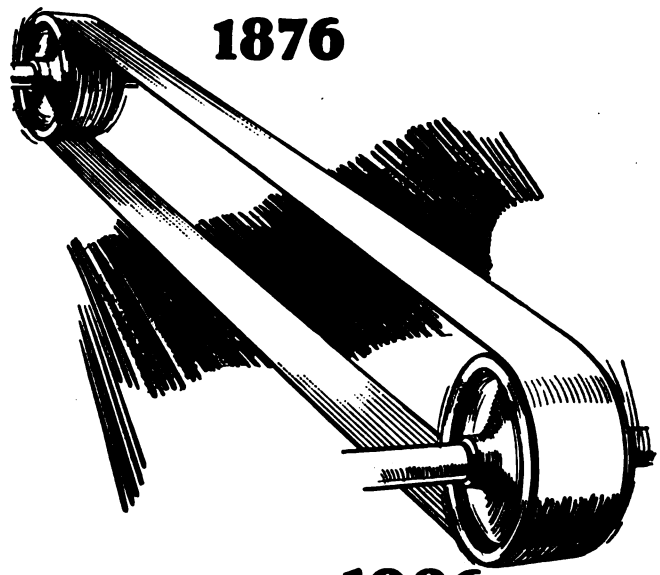
AMERICAN HIGH SPEED CHAIN CO.

Indianapolis, Ind.

NEW YORK, 50 Church St.
CHICAGO, Monadnock Block

Simplicity Plus 98% to 99% Efficiency

1876



1926

SEMICENTENNIAL OF A GREAT BELT

IN 1876 there were exhibited at the Centennial Exposition "—three monster leather belts—the largest 60 inches wide, 176 feet long, and weighing 1,130 pounds."

When General Grant opened the Exposition by starting the great Corliss Engine, this belt was first set in motion —*and it is in active service use today!*

For almost fifty years this "Centennial" belt has been running night and day, day in and day out, in a paper mill in Wilmington, Delaware. It has traveled around its pulleys a distance so great as to be almost incomprehensible—some 20,000,000 miles.

It has piled up this tremendous record under most adverse operating conditions. Meeting the heavy service of a paper mill, exposed to water and dampness, to extremes of heat and cold—what material other than leather could have possibly endured? For leather is an almost indestructible material—air and water have no effect upon it, and it is free from the usual elements of decay.

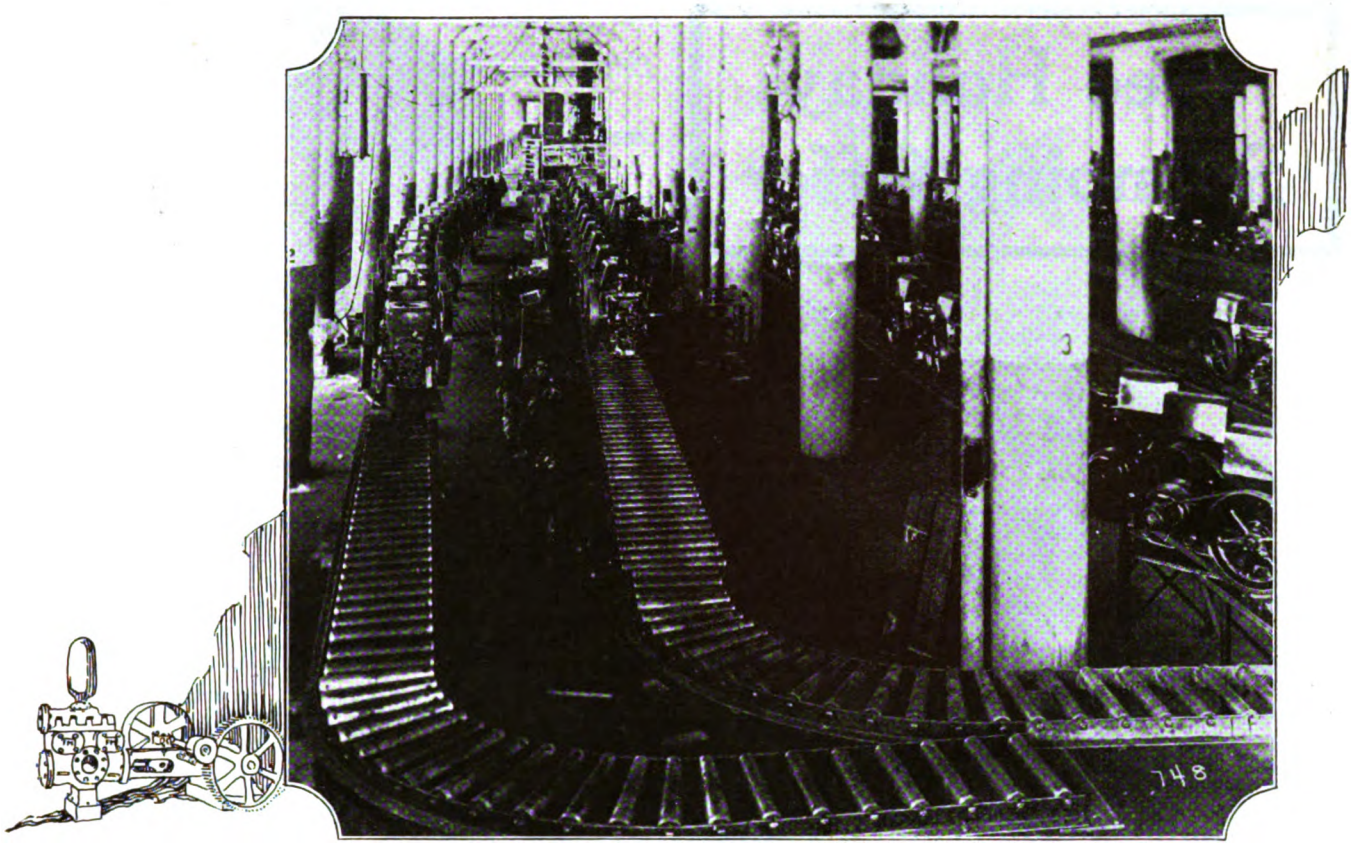
Beyond all question this famous old belt was one of excellent quality. But during the long years of its service there have been marked advances in the art of tanning, and it is quite certain that the first-quality leather belting on the market today is fully equal, if not superior, to the "Centennial" belt in quality, and capable of rendering equally remarkable service.

LEATHER BELTING EXCHANGE
417 Forrest Building Philadelphia, Pa.

Nothing takes the place of

LEATHER

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What makes Standard Conveyors Economical?

That's the question Fairbanks-Morse and Company wanted to know before installing the Standard System. They know now, and are daily receiving additional evidence from their own conveyors.

Standard Gravity Conveyors bridge the gaps between the cars, the material yards, the various shop operations, the assembly and storage houses to the shipping room. They eliminate much labor, require no power for operation and but little maintenance.

How a Standard Conveying System could help you, how it could reduce your handling costs and speed up production is a problem our engineers will gladly help you in solving. To call them in places you under no obligation. In the meantime we suggest that you write for a copy of catalogue IE 12.



STANDARD
CONVEYOR COMPANY,
NORTH SAINT PAUL, MINN.



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Free Holiday Stamping Offer

Until January 1, 1926, we will stamp your name, or a friend's name, in gold on the front cover of any McGraw-Hill Book. Orders for stamped books should be accompanied by proper remittance and, of course, stamped copies are not returnable.

Underhill—Coils and Magnet Wire
494 pages, 6 x 9, 197 illustrations, $4.00
A practical book on the principal classes of coils and the magnet wires from which they are constructed.

Underhill—Magnets
449 pages, 6 x 9, 467 illustrations, $4.00
A practical treatise on electromagnetic devices, their circuits and the specific forms and characteristics of electromagnets and permanent magnets used today.

Consoliver—Automotive Electricity
665 pages, 5½ x 8, 656 illustrations, $4.00
A new book on the construction, operation, characteristics and maintenance of automotive ignition, starting, lighting and storage battery equipment. The book presents information on practically all types and makes of automotive electrical and battery systems.

Annett and Roe—Connecting and Testing D-C Machines
237 pages, 6 x 9, 172 illustrations, $2.50
A practical presentation of the problems arising in the re-connecting of direct-current machinery for changes in speed and voltage, with methods of making tests for the locating of faults and directions for the making of repairs. Many diagrams and worked-out problems are included.

Dudley—Connecting Induction Motors
Second edition, revised and enlarged, 361 pages, 6 x 9, 289 illustrations, $3.00
A presentation of practical questions arising in winding and connecting alternating current motors. It includes 159 standard diagrams.

Del Mar—Electric Cables
208 pages, 6 x 9, 58 illustrations, $2.50
This book presents principles underlying the design, manufacture and use of electric cables of all important types for practically all purposes.

Schuhler—Electric Wiring
361 pages, 5 x 8, 305 illustrations, $2.50
The book covers the fundamentals of electric wiring thoroughly from the splicing and soldering of conductors to telephone wiring.

McGRAW-HILL
FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

☐ Send me the books checked with name stamped in gold on front cover. I enclose proper remittance and understand that stamped books are not returnable.

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(Name to Be Stamped)
This offer expires on Jan. 1, 1926

☐ Send me the books checked for ten days' free examination. I agree to return the books, postpaid, in ten days or to remit for them then.

.....Underhill—Coils and Magnet Wire, $4.00.
.....Underhill—Magnets, $4.00
.....Consoliver—Automotive Electricity, $4.00.
.....Annett and Roe—Testing D-C Machines, $2.50.
.....Dudley—Connecting Induction Motors, $3.00.
.....Del Mar—Electric Cables, $2.50.
.....Schuhler—Electric Wiring, $2.50.

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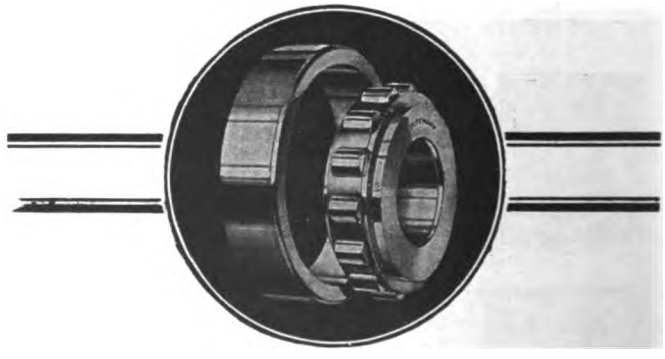
Economy

What a machine—or an improvement in a machine—costs, is of secondary importance. The big thing is what that machine will do, or how much that improvement will reduce costs or increase production. We've got to measure values by results—and by results only.

PRECISION BEARINGS

Incorporated in your machines will constitute a definite and tangible improvement—"Norma" Precision Ball Bearings where speeds are high and loads steady, "Hoffmann" Precision Roller Bearings for high speeds, heavy loads and shock or vibration. Our engineers have helped many a machine builder to add another factor to the economy of his product. Why not ask them?

NORMA-HOFFMANN BEARINGS CORPORATION
Stamford — Connecticut
PRECISION BALL, ROLLER AND THRUST BEARINGS



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A National Organization



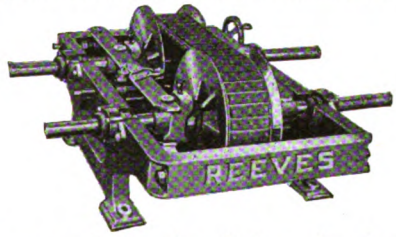
for

Accurate Speed Variation!

GET in touch with the REEVES representative nearest you and let him show you the advantages which accurate speed and variation will bring to the machines in your plant.

*Reeves-Bond Sales Company
Chicago
*Reeves Pulley Company
Detroit
Reeves Pulley Company
Toledo
*Manning Maxwell & Moore
New York & Boston
*Charles Bond Company
Philadelphia
W. E. Shipley Mach. Co.
Philadelphia
*Carey Mach. & Supply Co.
Baltimore
*J. A. Webb Belting Co.
Buffalo
*Strong, Carlisle & Hammond
Cleveland
*Link Belt Meese & Gottfried
San Francisco
*Link Belt Meese & Gottfried
Los Angeles
Link Belt Meese & Gottfried
Portland, Ore.
Link Belt Meese & Gottfried
Seattle
*E. M. & W. Engineering Co.
St. Louis
Neill-LaVielle Supply Co.
Louisville, Ky.
F. Raniville Company
Grand Rapids
Palmer-Bee Company
Detroit
Charles B. Scott Company
Scranton, Pa.
Ty-Sa-Man Machine Co.
Knoxville, Tenn.
Charlotte Supply Company
Charlotte, N. C.
Mine & Smelters Supply Co.
El Paso
Skinner Machinery Company
Dunedin, Fla.
T. L. Rose & Son
Pittsburgh
Dodge Mfg. Corporation
Cincinnati
Dodge Mfg. Corporation
Atlanta
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Chicago
Wm. G. Kerr
Pittsburgh
Vonnegut Machinery Company
Indianapolis
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Martin & Campbell Company
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Detroit
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Rochester, N. Y.
Alamo Iron Works
San Antonio
J. E. Dilworth Company
Memphis
*Chain Belt Company
Minneapolis
Boston Gear Works Co.
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Boston Gear Works Co.
New York

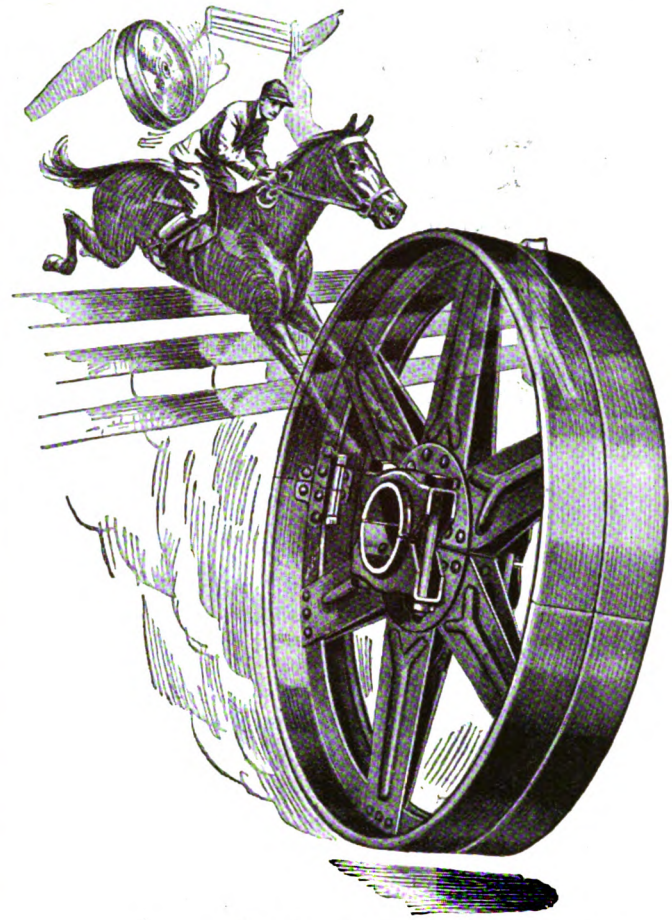
*—*indicates the representatives who carry a complete stock of REEVES Transmissions*



Ordinary speed changing devices give just steps in speed, but steps are not exact enough for best results. Often, the speed you need is between the steps, and the REEVES Transmission is the only way of getting the "in-between" speeds accurately. You get literally millions of speeds with the REEVES—any speed between fastest and slowest, even to the smallest fraction of a revolution. Accurate and dependable, always.

REEVES PULLEY COMPANY
Established 1887
Columbus, Indiana

REEVES
Variable Speed Transmission



The HURDLES *of* HORSEPOWER

THE horsepower that leaves the boiler spends a part of its force in overcoming the obstacles encountered in every lap of its travel from the boiler to the last machine.

There is resistance and waste in the transmission of every form of energy—the Hurdles of Horsepower.

But because of the scientific design and construction of "American" Pulleys and "American" Hangers (both of steel) these hurdles are lowered and transmission losses are cut to a minimum.

There are sound reasons for this power saving. You will find them clear and understandable. Write for them.

Visit our exhibit, Booth 530, at Power Show, Grand Central Palace, New York, N. Y., November 30th to December 5th.



PATENTED

The American Pulley Co.

Manufacturers of Steel Split Transmission Pulleys, Pressed Steel Shaft Hangers and Pressed Steel Shapes

4200 Wissahickon Ave. Philadelphia, Pa.

AMERICAN
PRESSED STEEL HANGERS PATENTED | STEEL SPLIT PULLEYS PATENTED

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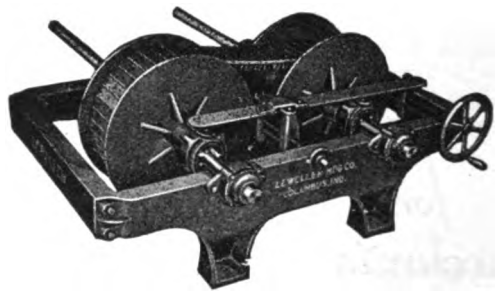
Why a Lewellen Transmission?

THE speed of any machine in the plant can be accurately controlled with a Lewellen variable speed transmission. It provides the best means known to modern practice for gradual and reliable variation of speeds. Old methods were unsatisfactory because they jerked from one speed to the next. The number of different speeds available was small. Accurate regulation was not possible.

With the Lewellen variable speed transmission, minute regulation and slight changes of speed—as well as wide variations—can be secured. The change is gradual, however—there are no jerks.

The Lewellen variable speed transmission makes it possible to control accurately the speed of any machine in the shop. Its use means distinct savings in production costs.

Lewellen Manufacturing Co.
Columbus, Ind.



The Lewellen complete ball bearing transmission is available from stock in sizes from 1 to 50 H. P. and in all speed ranges. It may be mounted on floor, wall, or ceiling. Equipped with hand, remote, or automatic control. The Lewellen ring oiling type of transmission, lower in price, is available for service where operating conditions do not warrant the complete ball bearing type.

LEWELLEN
Variable Speed
TRANSMISSION
1E-12E-RTG

Flexibility for Overhead Layout Means Lowered Operating Costs

Midwest Steel Stringers, which are themselves quickly and readily installed in any type of building, provide in advance for changes of every kind in your overhead layout.

New equipment is quickly installed—old equipment can be moved to the exact point where it is needed—and even belting can be tightened without cutting and relacing of belts. Changes in the location of any overhead equipment are made without skilled labor, without time-consuming field work, or boring of holes. The only tool required is a bolt wrench.

Your plant can profitably use Midwest Steel Stringers.

Let us send one of our engineers to show you how Midwest Steel Stringers will cut operating costs in your plant.



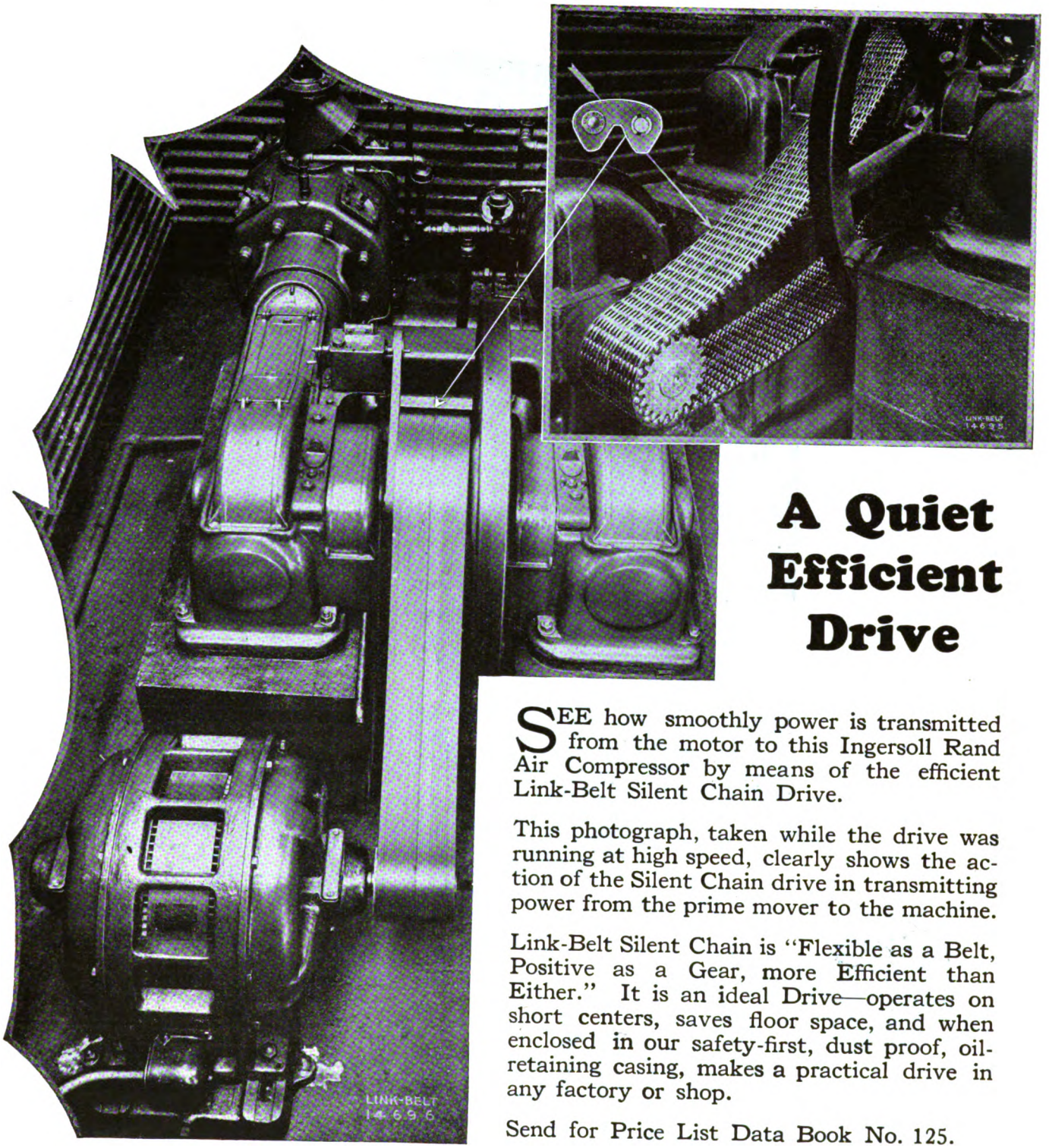
MIDWEST STEEL & SUPPLY CO. INC.
Bradford, Pennsylvania

Midwest Canada, Ltd., 83 Craig St., W. Montreal, Canada

Offices in Principal Cities

Midwest Pacific, Inc. Monadnock Bldg. San Francisco, Cal.

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A Quiet Efficient Drive

SEE how smoothly power is transmitted from the motor to this Ingersoll Rand Air Compressor by means of the efficient Link-Belt Silent Chain Drive.

This photograph, taken while the drive was running at high speed, clearly shows the action of the Silent Chain drive in transmitting power from the prime mover to the machine.

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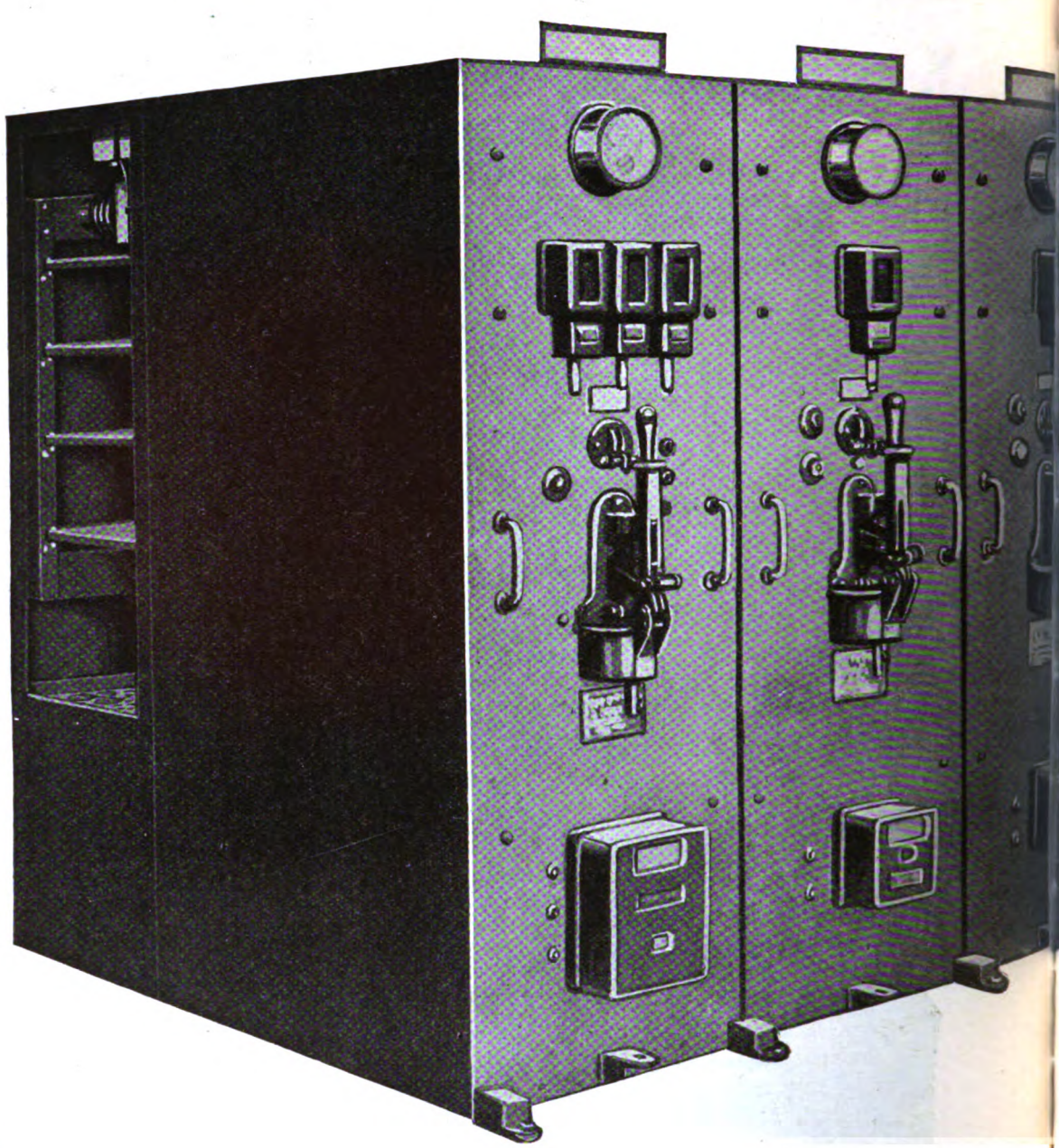
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SILENT CHAIN DRIVES

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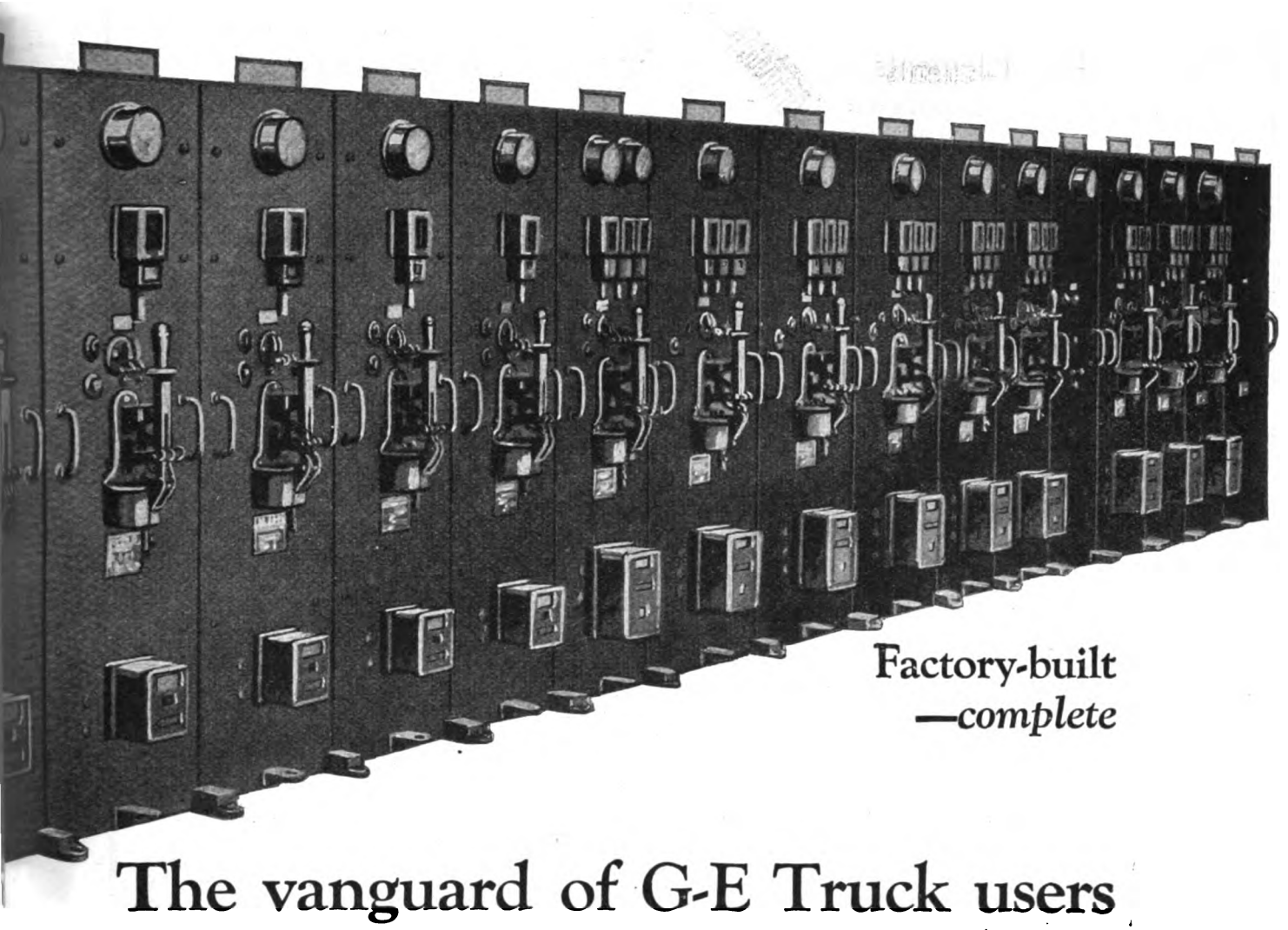
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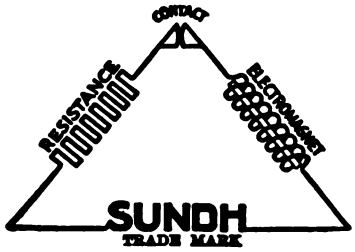
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The Elements of our Business



	Bulletin
Alarm, High and Low Liquid Level	3610-3615
Automatic Fire Pump Panels, Combined Hand and (See Panels, Fire Pump).	
Automatic Starters (See Starters, Automatic).	
Automatic Transfer Switches	5600
Brakes, Magnetic	9020
Circuit Breakers	3300-3315
Contactors (See Switches, Magnet).	
Control, Machine Tool	9000
Controllers, Elevator	9999
Elevator Controllers	9999
Fire Pump Panels (See Panels, Fire Pump).	
Float Switches	3600-3625
Hand and Automatic Fire Pump Panels, Combined. (See Panels, Fire Pump).	
Hand Operated Switches	3600
Hand Starters (See Starters, Hand).	
High and Low Liquid Level Alarm Switches	3610-3615
Indicator, Level, Liquid, Remote	3625
Level, High and Low Liquid, Alarm Switch	3610-3615
Level, Indicator, Remote	3625
Lighting Panels, Remote Control	7100
Low Levels, High and, Alarm Switches	3610-3615
Machine Tool Control	9000
Magnetic Brakes (See Brakes, Magnetic).	
Magnet Operated Valves	5700
Magnet Switches, A. C.	7000
Magnet Switches, D. C.	7500
Magnets	6500
Manual Fire Pump Panels (See Panels, Fire Pump).	
Manual Starters (See Starters, Hand).	
Panels, Fire Pump	3300-3320
Panels, Lighting, Remote Control	7100
Panels, Pressure Regulator (See Pressure Regulator, also Panels, Special).	
Panels, Special	5400-5422
Pressure Regulator, Gauge Type	4900-4902
Pressure Regulator Panels (See Panels, Special).	
Regulator, Pressure (See Pressure Regulator).	
Regulators, Speed (See Speed Regulators).	
Relay, Tumbler	7250
Remote Controlled Lighting Panels	7100
Remote Controlled Speed Regulators (See Speed Regulators).	
Remote Liquid Level Indicator	3625
Remote Switches (See Switches, Remote, also Switches, Magnet).	
Self Starters (See Starters, Automatic).	
Solenoids (See Magnets).	
Solenoid Operated Valves	5700
Special Panels (See Panels, Special).	
Speed Regulators, D. C.	5300-5320
Starters, Automatic, A. C.	5300-5300
Starters, Automatic, D. C.	5300-5300
Starters, Hand	5320
Starters, Hand, D. C.	5300
Starters, Manual (See Starters, Hand).	
Sump Switches (See Switches, Float).	
Switches, Float	3600-3625
Switches, Hand Operated	3600
Switches, High and Low Liquid Level Alarm	3610-3615
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Switches, Magnet, D. C.	7000
Switches, Remote (See also Switches, Magnet)	7300-7320
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Switches, Tank (See Switches, Float).	
Switches, Time	5600
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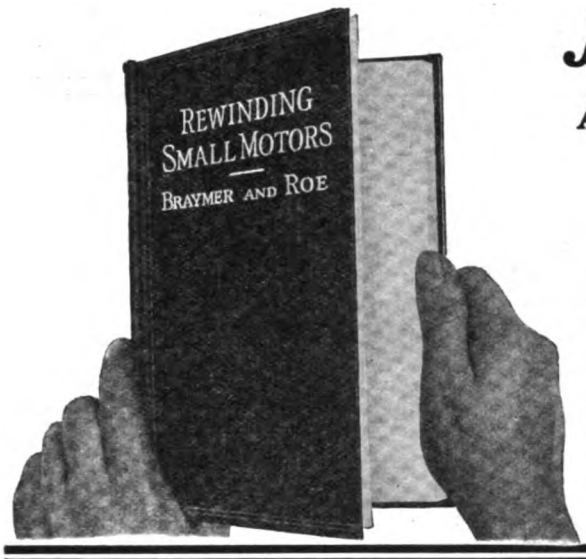
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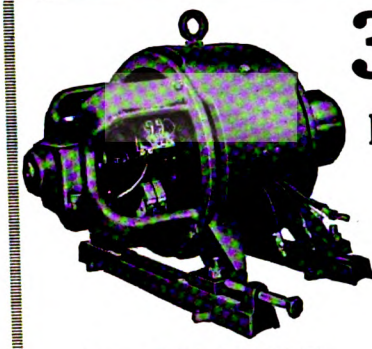
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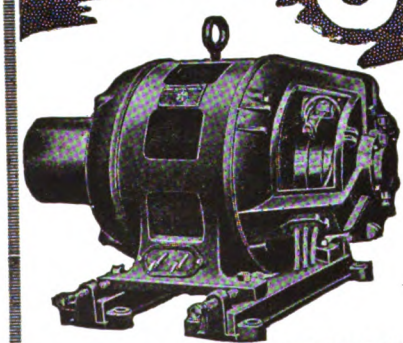
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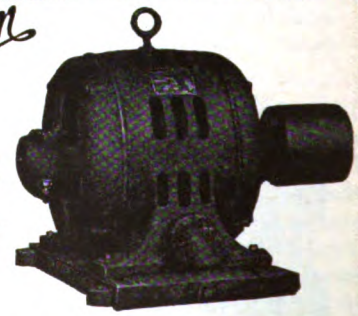
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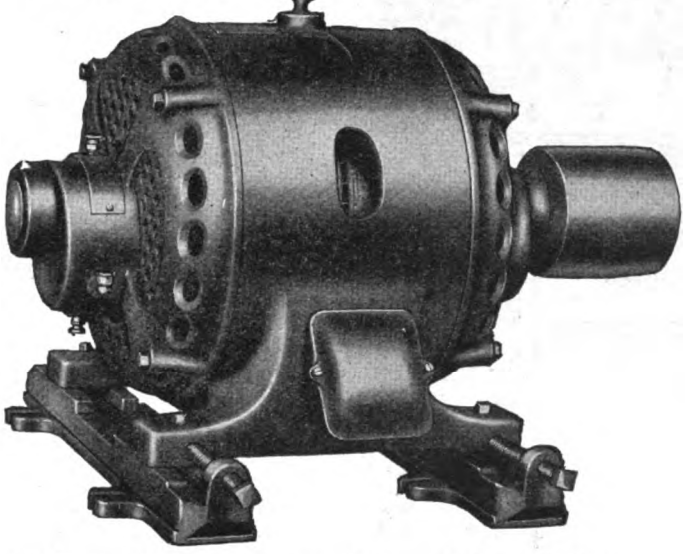
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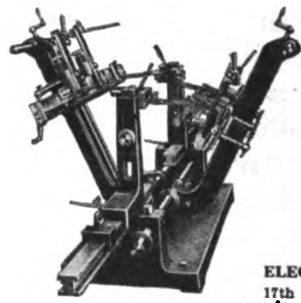


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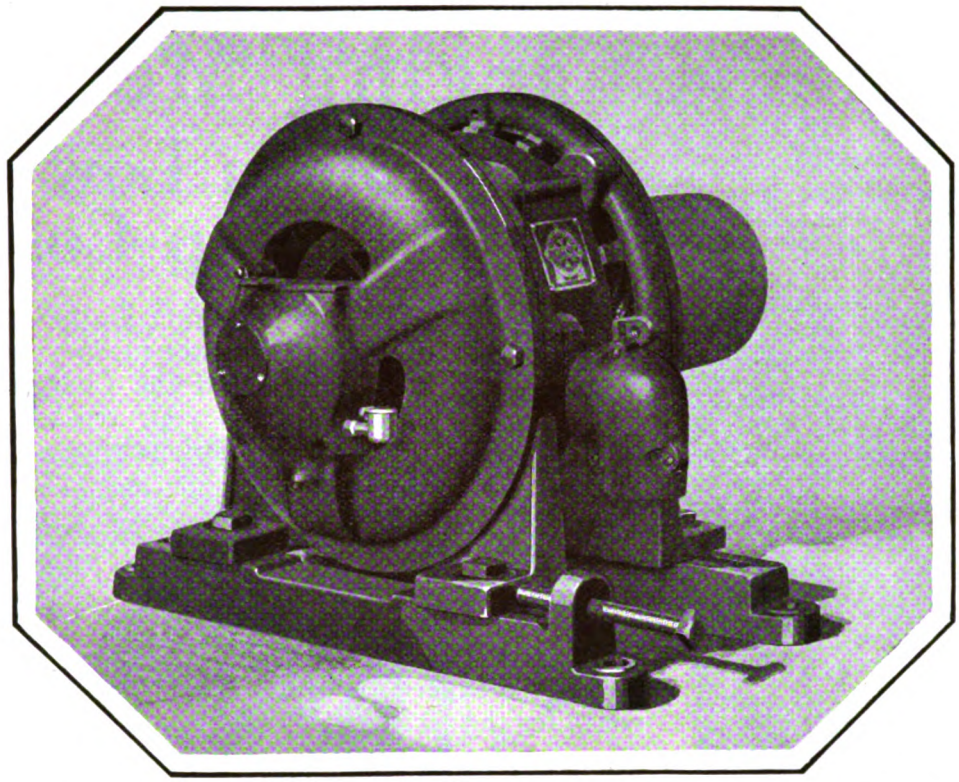
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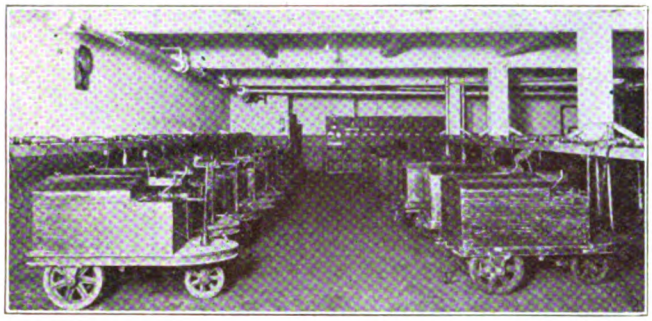
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Hertner Charging Methods

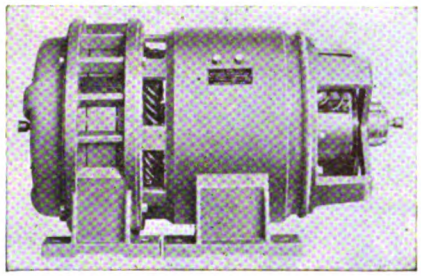


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Quite as important as the selection of the proper trucks to do your work is the selection of the Charging Equipment, to keep your trucks in perfect operating condition.

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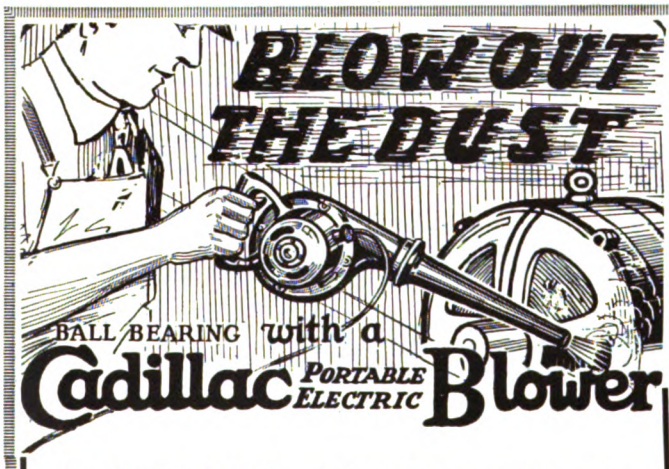


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IT PAYS to keep the windings of your electric motors free from dust, dirt and carbon, and thus prevent "shorts" and "burn outs". The CADILLAC delivers a powerful blast of dry air at the correct pressure to clean motors and similar equipment without injury.

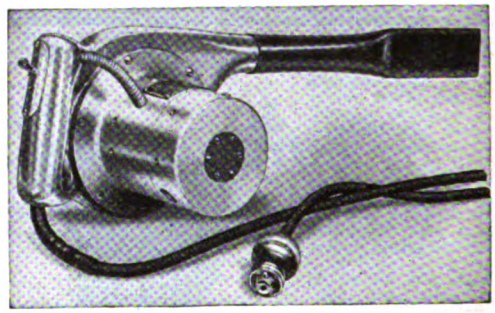
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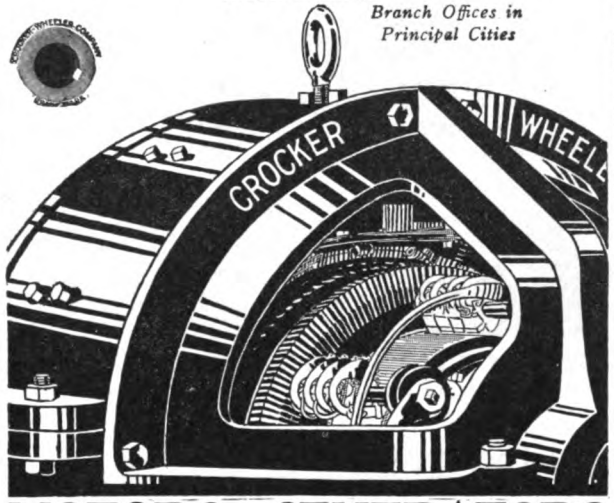
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CROCKER-WHEELER

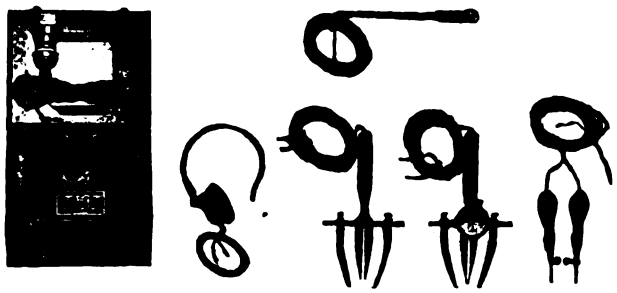
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D.C. and A.C. Motors from ½ H.P. up.
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AMPERE, N. J.
Branch Offices in Principal Cities



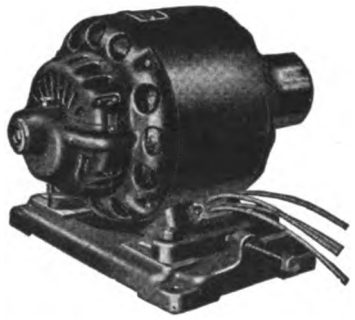
MOTORS & GENERATORS



CENTURY ARMATURE TESTER

Complete with all testing tools as illustrated $40.00.
Lamp, extra $2.25

CENTURY ELECTRICAL COMPANY
Manufacturers of Armature and Field Coil Testing Apparatus
Syracuse, N. Y.



Jeannin Single Phase Repulsion Induction Motors

¼ to 5 H. P.

The Jeannin Electric Co.
Toledo, Ohio



The First 15 Sold 50 More

AN original installation of 15 Valley Motors was placed in the factory of the Lampe Shoe Company the middle of 1922.

The work which these motors have to do consists of the pulling of line shafts, floors, and individual type shoe machine units. They run continuously all day long, and they are subject to frequent considerable overloads.

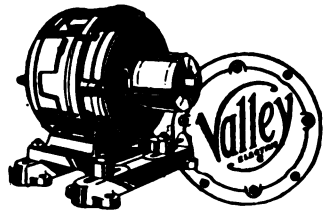
Since these motors were installed their performance has been so completely satisfactory that the management of this factory has installed more than 50 additional motors and assures us that future motors will be Valley Motors.

This is only another illustration of the service and satisfaction which buyers regularly get from Valley Ball Bearing Motors.

The delivery of continuous power with unusual operating economy and complete operating satisfaction is all in the day's work for Valley motors.

Before you buy or recommend another installation of motors, it will pay you to get all the facts about Valley Ball Bearing Motors. Write for descriptive booklet.

Motor Division
VALLEY ELECTRIC CO., ST. LOUIS, U S. A.
Branches in Principal Cities



Valley Electric

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ROLLER-SMITH
TYPE GSD
VOLT-AMMETER



A combination instrument that you cannot afford to be without

For the plant that wants trustworthy testing instruments at the lowest possible cost — this ROLLER-SMITH Type GSD direct current Volt-ammeter is of inestimable value. For all around general service in factories, laboratories and educational institutions this instrument is unsurpassed.

The ROLLER-SMITH GSD instruments are recognized in every industry as much needed aids to efficiency. This GSD Volt-ammeter is a real combination portable D.C. Volt-ammeter that takes up the space of only one instrument and yet costs much less than two separate instruments. Of convenient size, light-weight, rugged and—above all—accurate and reliable, it does double the work—for only a little more than half the investment.

Ranges up to 750 amperes and 750 volts in all sorts of combinations.

The Type GSD Volt-ammeter and other Type GSD instruments are fully described and listed in Bulletin A-210.

Your copy is ready for you. Use the coupon.

"Over thirty years' experience is behind every ROLLER-SMITH product"

ROLLER-SMITH COMPANY
Electrical Measuring and Protective Apparatus

Main Office:
229 Broadway, NEW YORK

WORKS:
Bethlehem, Penna.

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Baltimore	Dallas	Montreal	San Francisco
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Birmingham	Detroit	New Orleans	St. Louis
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Request for Roller-Smith Bulletin A-210

Name.....

Address.....

Company.....

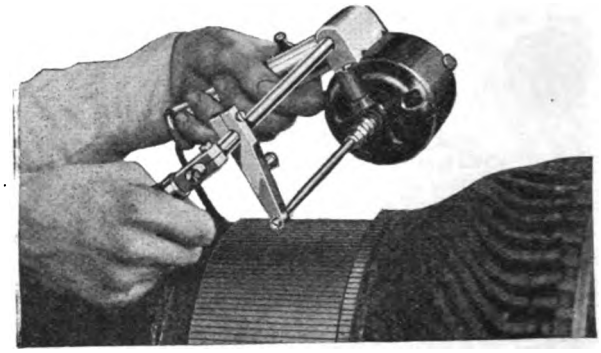
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Will be sent ON TRIAL so You can Judge its Merits

You can try a Hullhorst Mica Undercutter in your shop for ten days, and determine whether it is capable of doing the most efficient undercutting, in quickest time, at lowest possible cost.

Simply write "on 10 days' trial" on your order and mail it now. Or we'll gladly send descriptive pamphlets on our three types of undercutters, if you prefer.



HULLHORST Mica Undercutter No. 6, $44.00
Saves 75 to 90% of Time and Labor

The Hullhorst Micro Tool Co.

DEPT. 2 **TOLEDO, OHIO**



For controllers, compensators, starters, trucks, tractors, cars, etc.

Trigger-Lock Fingers with renewable tips.

Contact worn out? Costly renewal necessary? This is often the case with the ordinary finger, but not so with the Trigger-Lock Finger. It carries a tip which is easily and quickly reversed without removing the finger from controller. The finger has a spring action, a more delicate contact, giving reduced wear on all the controller segments.



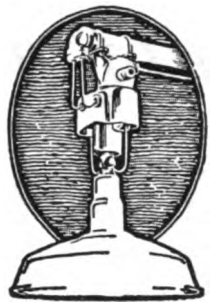
Learn about the many advantages of the Trigger-Lock Finger. Let us mail you valuable, illustrated catalog.

R-28

RUSSELL MANUFACTURING CO.

814 Bath Avenue **232 Westmount Drive**
NIAGARA FALLS, N. Y. **TORONTO, CANADA**

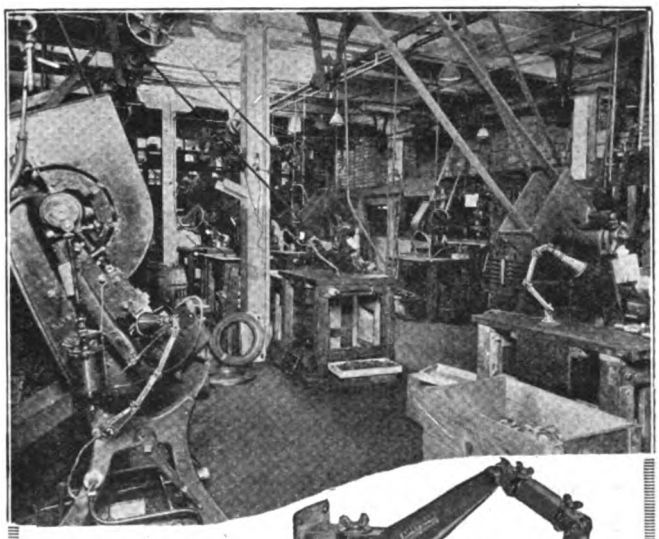
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It's the Polish on the business side of the reflector that puts the light where you want it

And the Thompson Safety Lowering Switch solves the reflector cleaning problem. It enables the work to be done on the ground *easily* and safely. How? Get Catalog B-25 for details of this inexpensive device.

The Thompson Electric Co.
1438 W. 9th St. Cleveland, O.



BOOST PRODUCTION

6 STYLES
Ceiling Fixtures
Wall Brackets
Floor Fixtures
Bench Fixtures
Machine Fixtures
Portables



If your production is falling off and your employees are listless and indifferent—look to your lights! Good light—localized light—is an essential of greater production.

American Adjustable Fixtures, furnished with either standard flat brackets or conduit fixtures, are the real solution to the problem of Better Industrial Lighting.

Write now for our new catalog.

AMERICAN FIXTURE COMPANY
232 W. Water St. Milwaukee, Wis.



Showing ease of removing Reflector Two-Piece R. L. M. ABolite by simply compressing Spring in Neck.

Shallow Dome ABolite for wide angle distribution or general outdoor lighting.



Deep Bowl ABolite for concentrated light directly below reflector.



Angle Bowl ABolite for use where neither the R.L.M nor the Deep Bowl are practical. An ideal unit for window aand sign lighting.



Just as easy to change as it looks with the added advantage of having the proper illumination for each and every industrial requirement.

Our Catalog shows many other ABolite types of reflectors. Just ask for E-178.

A B Products Division

The NATIONAL SCREW & MFG. Co.
Cleveland, Ohio

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Why not a Safety Zone in Industrial Selling?

The Peace Pact at Locarno—

forever bans war by setting up a safety zone between two traditional enemies. Neither can cross the "dead line" without bringing to the other's aid the arms of great neutral nations.

Why not a safety zone in industry beyond which the seller may know he cannot go without penalty of loss?

If every manufacturer who sells to industry would set up a safety zone which would clearly mark the border between profitable and unprofitable selling, he would take a step as momentous to his own business as Locarno is to world peace.

The McGraw-Hill Four Principles of Industrial Marketing are industry's safety zone. They safeguard profits as surely as the new Rhine barrier insures peace.

1926 is approaching. Some manufacturers will enter it with sales plans based on hunches. Others will enter with markets determined and programs outlined that will produce sales at the lowest cost.

Which plan will you follow?

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IF YOU ELECT to apply the McGraw-Hill Four Principles of Industrial Marketing, here are the steps to take:

1. *Market Determination.* Study each market for your product. Weigh its potential. Determine which industries are the profitable ones to cultivate. The place to start is with your own books. Classify your sales by natural buying groups. Then compile data on each industry in which your product can be used. Compare the two and you will see clearly where your biggest opportunity lies.

2. *Buying Habits.* Study the buying habits of the industries you decide to sell. Find out who are the buyers and how they buy. This will save the expense and wasted effort of "barking up the wrong tree."

3. *Channels of Approach.* Having located the real buyers direct your selling on them. Support your sales effort with advertising in the publications which have the greatest influence with these buyers—the ones they look to for information.

4. *Appeals that Influence.* Don't talk generalities in your advertising. Talk shop in the buyers' own language. Tell them how your product will increase the productiveness of their plants or will reduce costs. Performance facts are what interest them most.

Here you have a plan for successful selling which is simplicity itself. There is no patent on it, for the McGraw-Hill Four Principles of Industrial Marketing are plain common sense, coded and applied to the job of selling to industry.

1926 is approaching. If you want to apply the McGraw-Hill Four Principles of Industrial Marketing to your 1926 program, follow the above formula. If you need guidance, the McGraw-Hill Company may be able to help you. Obviously we cannot develop sales plans for many, but we can supply information and suggest methods which will make simpler a manufacturer's own plan building.

Fifty years of intimate contact with industry have given us a knowledge of markets and buying habits which is proving of great value to many manufacturers.

1926 is approaching. If we can be of service to you, please feel free to call on us. Our book "Industrial Marketing" will give you a good start. It will be sent gratis to any manufacturer who sells to the industries covered by the Mc-Graw-Hill publications.

This advertisement is the seventh of the series which is appearing in the *New York Times, Philadelphia Public Ledger, Pittsburgh Gazette-Times, Chicago Tribune, Cleveland Plain Dealer, Detroit Free Press, Chicago Journal of Commerce* and *New York Herald-Tribune;* in *Printers' Ink, Advertising and Selling Fortnightly, Class, Sales Management,* and in the McGraw-Hill Publications. The purpose of these advertisements is to arouse a national appreciation of the need for improving industrial sales efficiency, and to awaken a keener interest in the correct principles of industrial selling.

McGRAW-HILL COMPANY, INC., NEW YORK, CHICAGO, PHILADELPHIA, CLEVELAND, ST. LOUIS, SAN FRANCISCO, LONDON, PUBLISHERS OF

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REACHING A SUBSTANTIAL MAJORITY OF THE POTENTIAL BUYERS IN THE INDUSTRIES THEY SERVE

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JOURNAL OF ELECTRICITY
ELECTRICAL MERCHANDISING

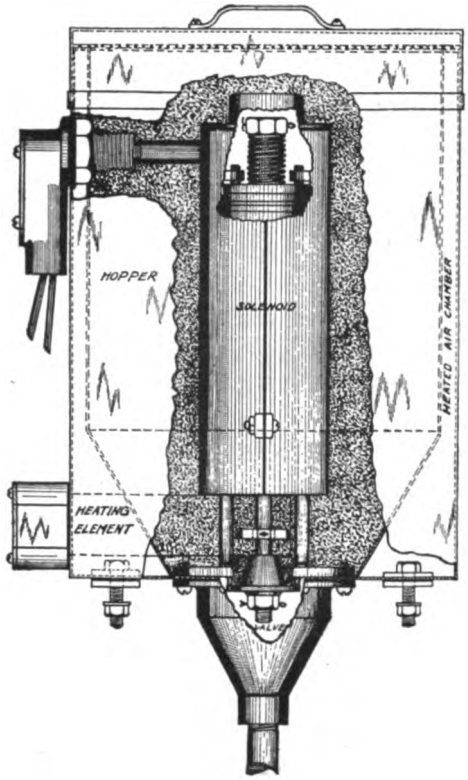
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POWER • AMERICAN MACHINIST
CHEMICAL & METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEER

Overseas
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INGENIERIA INTERNACIONAL

Construction & Civil Engineering
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Transportation
ELECTRIC RAILWAY JOURNAL
BUS TRANSPORTATION

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N-L



Sand Runways without stopping the crane—

Do It Economically With

THE LINTERN ELECTRO MAGNETIC SANDER

The old hand-and-bucket method of sanding is dangerous and costly. By means of this modern sander you sand your tracks on the instant and actually prevent skidding, wheel spinning and those strains to crane and runways that mean expense—you bring safety into sanding in its highest degree—you keep your cranes in continuous operation.

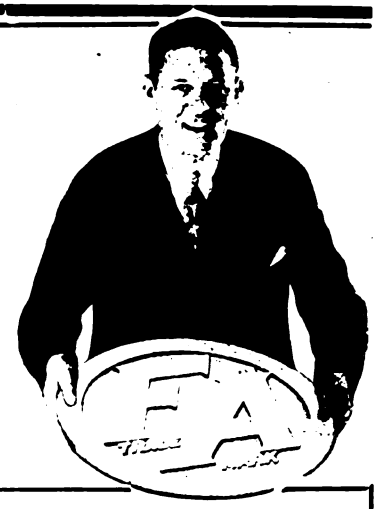
The Sanders are operated by an N-L Momentary Contact Switch (by hand or foot) located in the operating cage of the cab. When pressure is removed, the sander valves automatically and immediately close.

Your request will bring our details.

THE NICHOLS-LINTERN CO.
7960 Lorain Avenue Cleveland, Ohio

Represented in Canada by Railway & Power Engr. Corp.
Toronto, Ontario

First always



Here Is Insurance Against Costly Shut-Downs

Insurance—because there are no shut-downs from panelboard trouble when FA Panelboards are on the job. FA Panelboards could be built no better for your specific requirements if they were constructed according to your plans—and cost entirely disregarded. Every FA part is extra heavy, with an over amount of service built in. Every part is standardized. All work possible is done in the factory and FA Panelboards are complete when shipped. Installation costs are thereby lowered and FA Panelboards actually cost you less.

THERE IS A TYPE FOR YOU

Let us tell you about it. Write for details, descriptive FA catalog full of panelboard information and complete estimates. All furnished free!

Frank Adam
ELECTRIC COMPANY
ST. LOUIS

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Let's Get Acquainted
Write For This Book



FREE

No charge is made for Catalog D — a valuable data book and catalog of insulations. All we ask is that you state on your request what company you are identified with—or ask for it on your company letterhead.

TODD PROCESSES

are especially adapted to the manufacture of insulating varnishes. By its use deleterious substances are removed that cannot be taken out by other methods.

Sterling Varnishes are unusual because of their
elasticity combined with mechanical strength
endurance when exposed to service conditions
uniformity year in and year out
low cost due to the application of modern production methods

Avoid substitution, make sure that each package bears the mark "Todd Processes" as well as the word Sterling.

STERLING VARNISH
THE STERLING VARNISH COMPANY, PITTSBURGH, PA.

Insulating Varnishes and Finishing Enamels
our specialty

COIL VARNISH
CLOTH VARNISH
CORE PLATE VARNISH
MOTOR FINISHING ENAMEL
FLAT BLACK ENAMEL
TRANSFORMER PAINTS

Impregnating Compounds and Reducers
Baking Enamels for finish and durability are not excelled

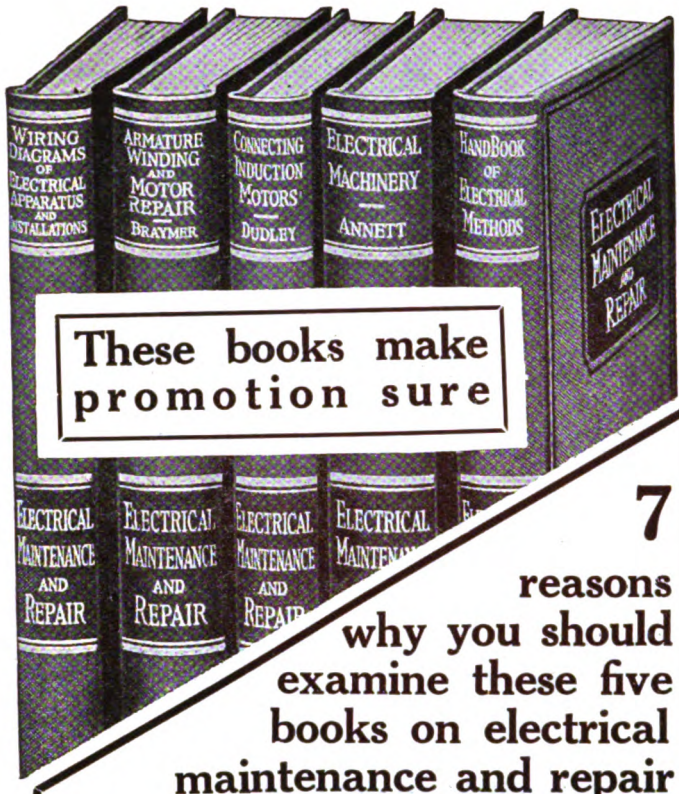
Impervious Varnish Company
General Offices, Pittsburgh, Pa. **Works, Rochester, Penna.**

KLEIN TOOLS
Since 1857



Mathias Established 1857 **KLEIN** & Sons Chicago Ill USA

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7 reasons why you should examine these five books on electrical maintenance and repair

1. The five books in this library discuss actual repair jobs and show you step by step what to do when anything goes wrong.
2. They show you how to locate and remedy motor and generator troubles.
3. They show you how to reconnect motors to meet any condition of voltage, phase, frequency and speed.
4. They give you suggestions for preventing electrical machinery troubles.
5. They cover fully the rewinding of motors.
6. They present information that will help you get better service out of your electrical equipment.
7. They give you tables, data, kinks and diagrams that you will find of priceless value every day on every job.

Free examination — no money down — only $2.00 in ten days and $2.00 a month until paid

Fill in and mail the coupon attached and we will send you the entire set of five volumes for ten days' Free Examination. We take all the risk—pay all charges. You assume no obligation—you pay nothing unless you decide to keep the books. Then $2.00 in ten days and the balance at the rate of $2.00 a month. Send the coupon NOW and see the books for yourself.

McGRAW-HILL
FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

Gentlemen:—Send me the **Library of Electrical Maintenance and Repair**, all charges prepaid, for 10 days' Free Examination. If satisfactory I will send $2.00 in ten days and $2.00 a month until $14.00 has been paid. If not wanted I will write for shipping instructions.

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City and State .....

Firm or Employer .....

Occupation .....I. E. 12-1-25



DRAGOMAN

No one in Egypt gives you a more hearty welcome than the dragoman.

He knows all languages, has melodramatic descriptive qualities and loves newcomers in direct proportion to the amounts they spend at the bazaars (on which he gets 10%).

He's a wonderful man while he keeps up his chatter, but your cold-grey-dawn analysis of him is that he's a big humbug.

Talk is a wonderful thing, properly handled, and it sells a lot of funny carbon brushes.

Morganite brushes, however, are not sold under the cloak of a spiffy story or through the din of a hearty laugh.

They are sold solely on performance and they themselves must deliver the sales arguments.

Morganite engineers prescribe a type of Morganite to fit the service *exactly*.

That type must save money for the user. If it doesn't then—But why continue, it *must* and it *does*.

That's that.

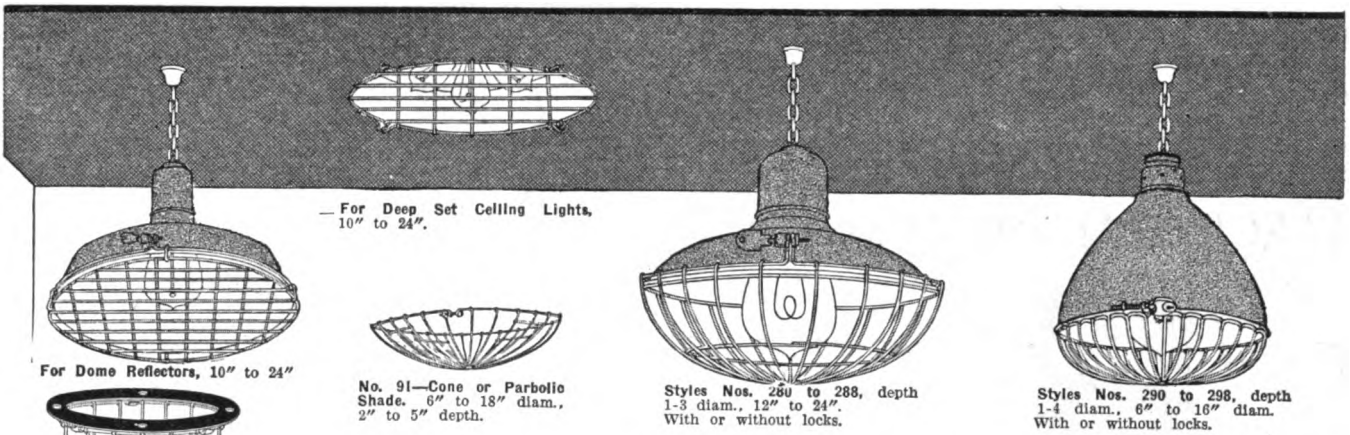
Morganite Brush Co., Inc.

Main Office and Factory
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS

***Pittsburgh*, Electrical Engineering & Mfg. Co., 909 Penn Ave.**
***Cincinnati*, Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.**
***Cleveland*, Electrical Engineering & Mfg. Co., 422 Union Building.**
***Baltimore*, O. T. Hall, Sales Engineer, 1926 Edmondson Ave.**
***Revere, Mass.*, J. F. Drummey, 75 Pleasant Street.**
***Los Angeles*, Special Service Sales Co., 502 Delta Building.**
***San Francisco*, Special Service Sales Co., 202 Russ Building.**
***Toronto, Can.*, Railway & Power Engineering Corp., Ltd., 101 Eastern Avenue.**
***Montreal, Can.*, Railway & Power Engineering Corp., Ltd., 326 Craig St., West.**
***Winnipeg, Can.*, Railway & Power Engineering Corp., Ltd., P. O. Box 325.**

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For Dome Reflectors, 10″ to 24″

—For Deep Set Ceiling Lights, 10″ to 24″.

No. 91—Cone or Parbolic Shade. 6″ to 18″ diam., 2″ to 5″ depth.

Styles Nos. 280 to 288, depth 1-3 diam., 12″ to 24″. With or without locks.

Styles Nos. 290 to 298, depth 1-4 diam., 6″ to 16″ diam. With or without locks.

Style No. 51—Heavy Ceiling Guards Made with detachable flat iron rings. Also made with hinge and hasps 8″ to 22″ diam. 5″ to 16″ depth.

No. 54—Heavy Foundry or Wall Guards—Well stayed all around. Opens on hinges. 11″x5″x5″. 12″ x6″x6″.

Style No. 180 — "Webster" Cluster Guards. Depth 1-2 diam.; lightweight made with bolt clamp; 10″ to 24″. Heavy with hinge, etc.

Send today for our catalog and price list.

You can now get Morse Guards for industrial lighting reflectors

Our line of lamp guards has been expanded to include heavy, well made guards for dome reflectors and ceiling lights in mills, railroads, industrial plants, etc.

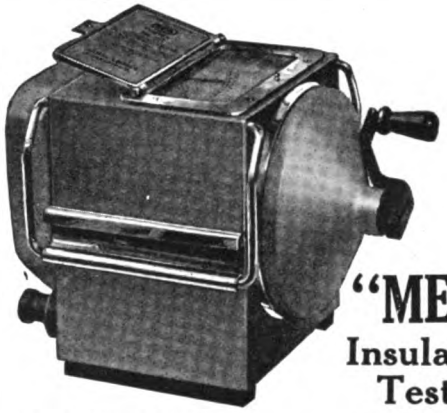
All guards are made so rigid that when fastened around the reflectors they are as strong and solid as part of the reflector itself. Hinges and hasps are furnished on all wire guards for ceiling lights.

Our regular stock guards fit any style reflector from 6 inches to 24 inches diameter and from very shallow depths up to 18 inches.

Special guards made to order.

Frank W. Morse Company

289 Congress St., Boston, Mass.



"MEG" Insulation Tester

Engineers who "Megger" tell us that the "Megger" Method is the best way of checking the condition of electrical equipment and of preventing unexpected breakdown.

The "Meg" Insulation Tester is our newest and most convenient device for the purpose. It is inexpensive and reliable. You merely connect one terminal to ground and the other to the conductor of a motor, generator, wire, transformer or cable, turn the crank at about 120 r.p.m. and read the scale—no calculations. Anyone can perform the test; and it gives information which cannot be obtained as easily in any other way.

The "Meg" is a "Megger" of small size and light weight which generates 500 volts d.c. and reads up to 100 megohms. Try it and you will find, as many others have found, that it pays for itself very quickly.

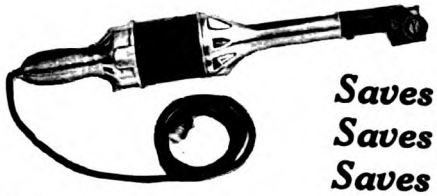
The "Meg" is housed in a neat aluminum case as shown, it stands 6¼″ high and weighs 6¾ lbs. Price including canvas carrying case $135, f.o.b. Philadelphia.

Write for Pocket Manual 1060-E: Concerning Insulation Testing With Special Reference to the "Meg"

JAMES G. BIDDLE

1211-13 Arch Street
PHILADELPHIA, PA.

Aurand Commutator Slotter



Saves Time
Saves Labor
Saves Expense

Undercuts mica in a fraction of the time it takes to do the job by hand.

Follows the line of mica and will operate over ridges. Cuts smooth to a uniform depth. Eliminates the necessity of removing armature and placing in a lathe, saving time and attendant danger of damage.

Made in two models

"The Aurand" for large commutators and heavy duty.

"The Aurand, Jr." for small commutators and light duty.

Hand operated, motor driven, portable, Universal type motor furnished for 110, 220, 250 or 275 volt services.

OTHER GREEN EQUIPMENT

ACME Commutator Stones
ACME Commutator Cement
ACME Commutator Polish
ACME Armature Washing Fluid
EMERY 4 Cyclone Blowers and Vacuum Cleaners
L. & H. Turning and Grinding Tools

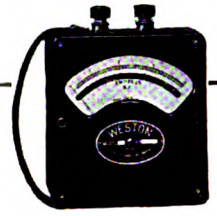
Just drop us a line and we will tell you all about our Free Trial Offer.

Green Equipment Corporation

330 So. Dearborn Street **Chicago, Ill.**

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PORTABLE
Precision in
ELECTRICAL MEASUREMENTS



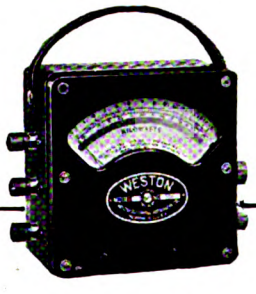
Weston Model 433
Portable Voltmeter

FREQUENTLY power losses and breakdowns occur at remote points and at inopportune times—yet it is possible to take anywhere—accurate, dependable testing equipment for thorough-going measurement in the field—Weston Juniors.

Weston Junior Portable Instruments consists of Voltmeters, Ammeters and single phase Watt-meters, of a small convenient size. They are contained in Bakelite cases meant for rough handling yet light and compact.

Engineers use Weston Juniors with the same dependence upon their precision and long-life as in the larger instruments.

Weston Model 432
Portable Voltmeter



For further information address

WESTON ELECTRICAL INSTRUMENT CORPORATION

136 Weston Avenue, Newark, N. J.



STANDARD THE WORLD OVER
WESTON
Pioneers since 1888



A Victim—
but Unaware!

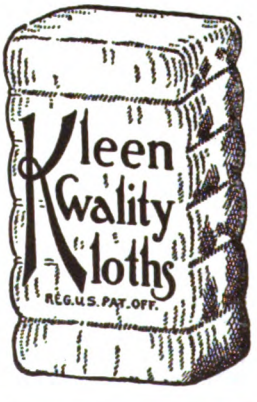
THE insidious thing about unsterilized wiping rags is that their lurking danger cannot be seen. There may be millions of disease carrying germs in the folds of the whitest wiper—*if it has not been properly treated*—ready to attack any minor cut or injury. Your workers pay the toll with lost members or disease; and the consequent disrupted working forces make your production costs soar.

Kleen Kwality Kloths
Sterilized, Lintless

Kleen Kwality Kloths are sanitary—and lintless too. They are washed in chemicals, boiled in live steam and then baked at 225° F. That's the reason they are as sterile as hospital gauze. You can get these wipers in any quantity, from 10 lb. packages to 1,000 lb. bales. Specify them—they cost no more.

AARON FERER & SONS
ST. LOUIS

Branches in main industrial centers of U. S. A.



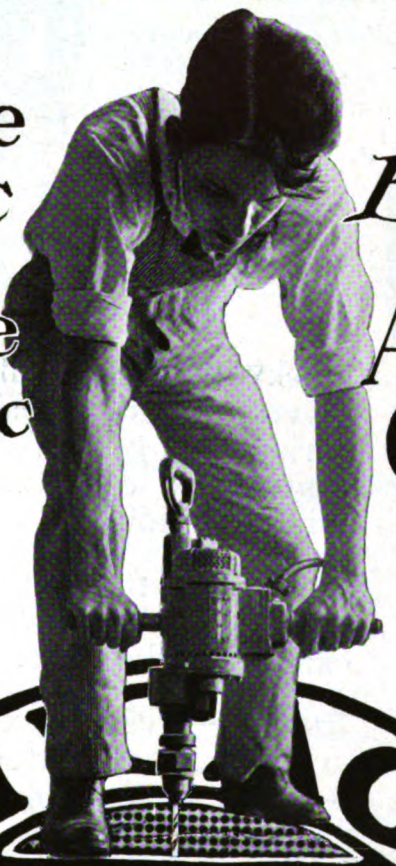
This mark is Your Guarantee of Sterilization. Demand It!

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Little Giant

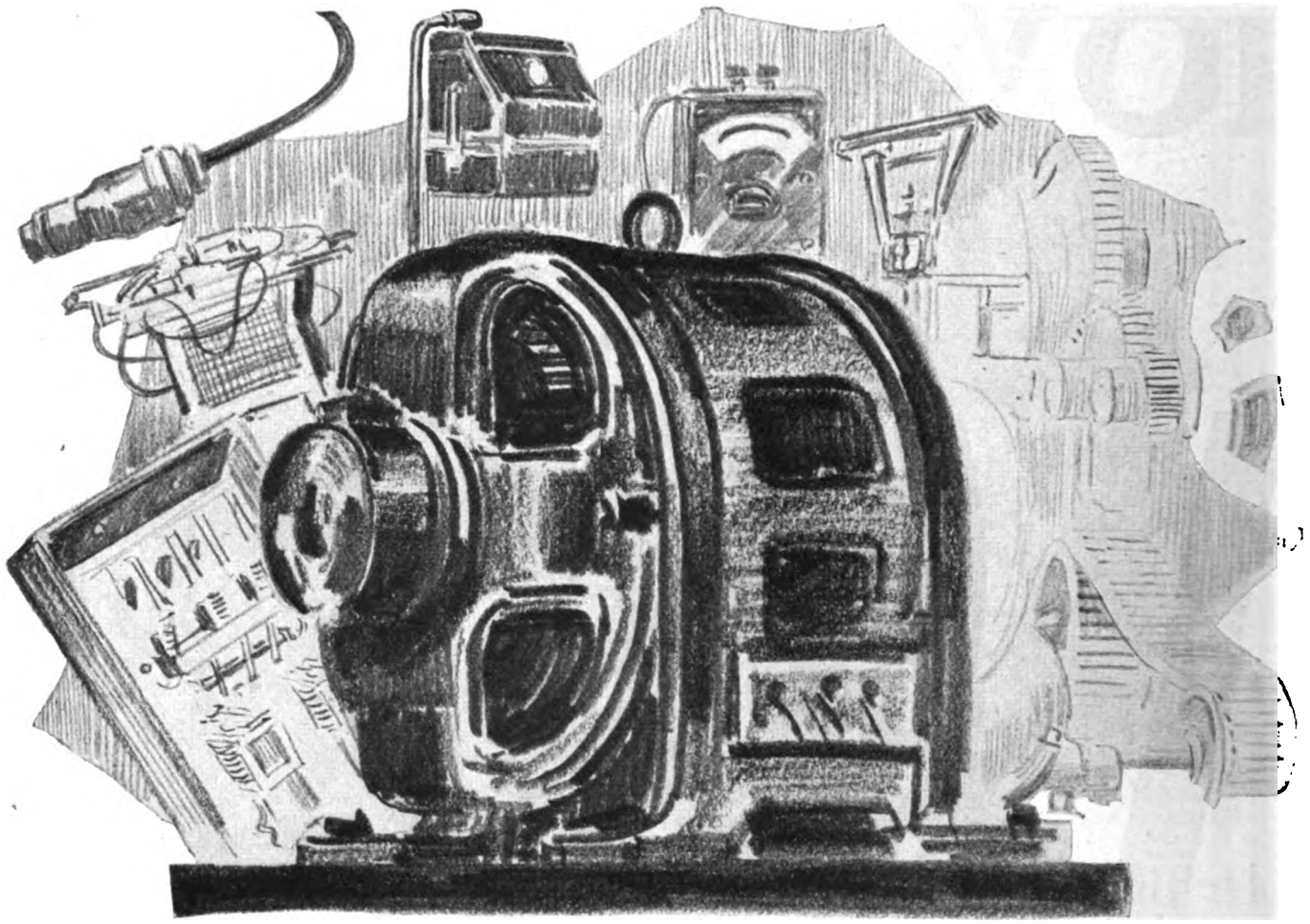
Portable Electric and Portable Pneumatic Drills



Are Equipped With Almond Chucks

CHICAGO PNEUMATIC

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Look beyond the motor

Consider what a motor represents in conduit fittings, in switches, in starters, in wiring supplies, in line shafts, belts, chains, hangers, bearings, etc.

The motor is truly a gauge to a considerable market, and it is your problem to reach this market and tell your story to the operating men in the industrial plant. But reach the right men, the men who are responsible for the selection and operation of the electrical and mechanically related equipment.

Industrial Engineer will take your message to the right men once a month. Consider it as a part of your organization.

Forms for the January issue close December 20th

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

A McGraw-Hill Publication. A.B.C.—A.B.P. 7 South Dearborn St., Chicago, Ill.

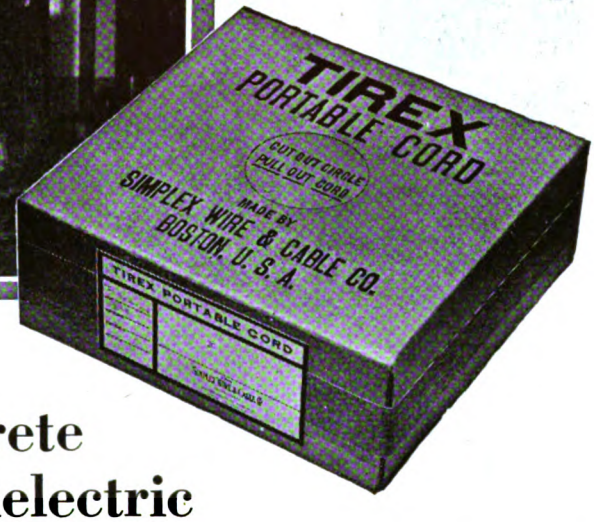
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Tirex

Portable Cord

for every electric drilling need!



TIREX NEVER KINKS

Drilling through concrete with a pneumelectric

The purchasing agent of a western factory writes us as follows:

"We are entirely pleased with the service that we have received from Tirex Portable Cord so far and from all appearances this cord will last indefinitely. We have made up our mind to specify Tirex hereafter for all the portable cord used in the factory."

On drills, grinders and all portable tools—Tirex does the job well and lasts a long time. It saves time because the tool is always on the job.

Sharp edges, rough ground, oil, grease or moisture have no appreciable effect upon TIREX ALL-RUBBER PORTABLE CORD. Tirex will stay on the job until the job is finished and will come back to the tool-room ready for more work. Send today for samples and prices.

If you are an electrical engineer, contractor or wireman, you need the Simplex Manual to help you in your daily work. The Simplex Manual contains, in addition to information regarding Simplex Products, tables and data for ready reference. One hundred sixty-four pages of valuable, condensed information—and it fits right into your pocket.

For convenience, Use the Coupon.



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MANUFACTURERS
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CHICAGO SAN FRANCISCO NEW YORK

Simplex Wire & Cable Co.,
201 Devonshire St., Boston, Mass.

Gentlemen:—

Please send me the Simplex Manual. ☐

Please send quotation on Tirex Portable Cord. ☐

Size.....No. of Conductors.....

Voltage.....Feet.....

Name.....

Position.....

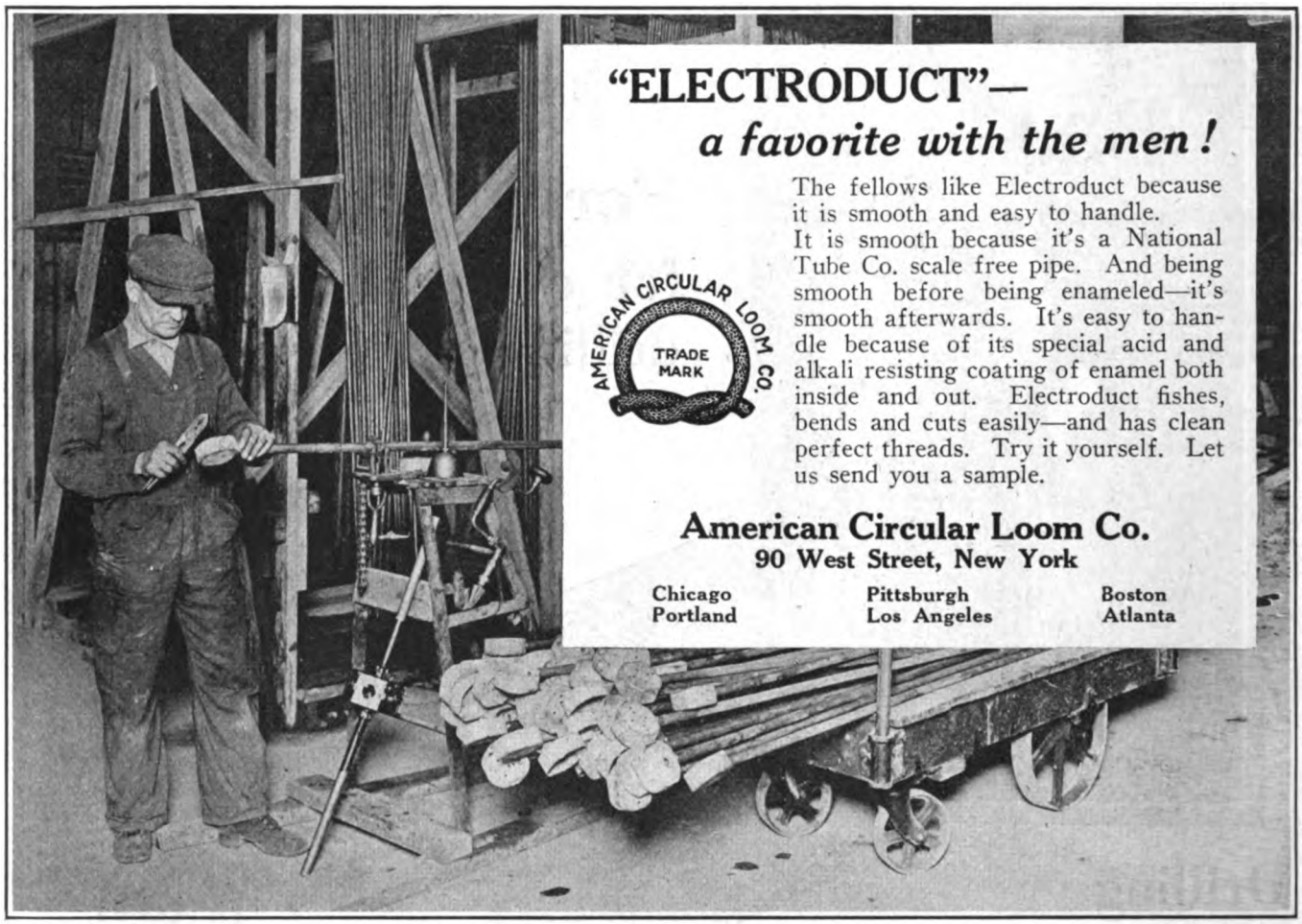
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City.....

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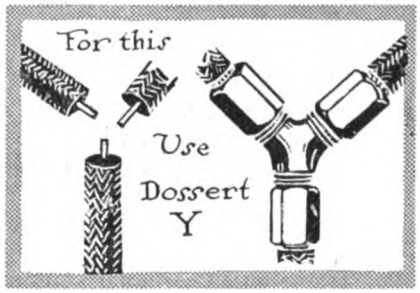
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a favorite with the men!

The fellows like Electroduct because it is smooth and easy to handle.
It is smooth because it's a National Tube Co. scale free pipe. And being smooth before being enameled—it's smooth afterwards. It's easy to handle because of its special acid and alkali resisting coating of enamel both inside and out. Electroduct fishes, bends and cuts easily—and has clean perfect threads. Try it yourself. Let us send you a sample.

AMERICAN CIRCULAR LOOM CO. TRADE MARK

American Circular Loom Co.
90 West Street, New York

Chicago Pittsburgh Boston
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Y and wherefore

The why and wherefore of the acceptance of the Dossert line of connectors is summed up in the Dossert Tapered Sleeve principle.

This principle made possible the safe use of solderless connections.

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TAPES INSULATING

Awebco Brand Tapes and Webbings make better insulation because they are most closely woven, are uniform in texture and free from defective spots or flaws.
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Heavy Stay Binding .018 in. Thick

Use our sample book as your guide in choosing suitable weights and styles of insulation tape.

Sample Books sent on request.

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300 Brook Street, Pawtucket, Rhode Island
New York, Chicago, Cleveland, Pittsburgh, St. Louis, etc., etc.

SALAMANDER WIRES and CABLES

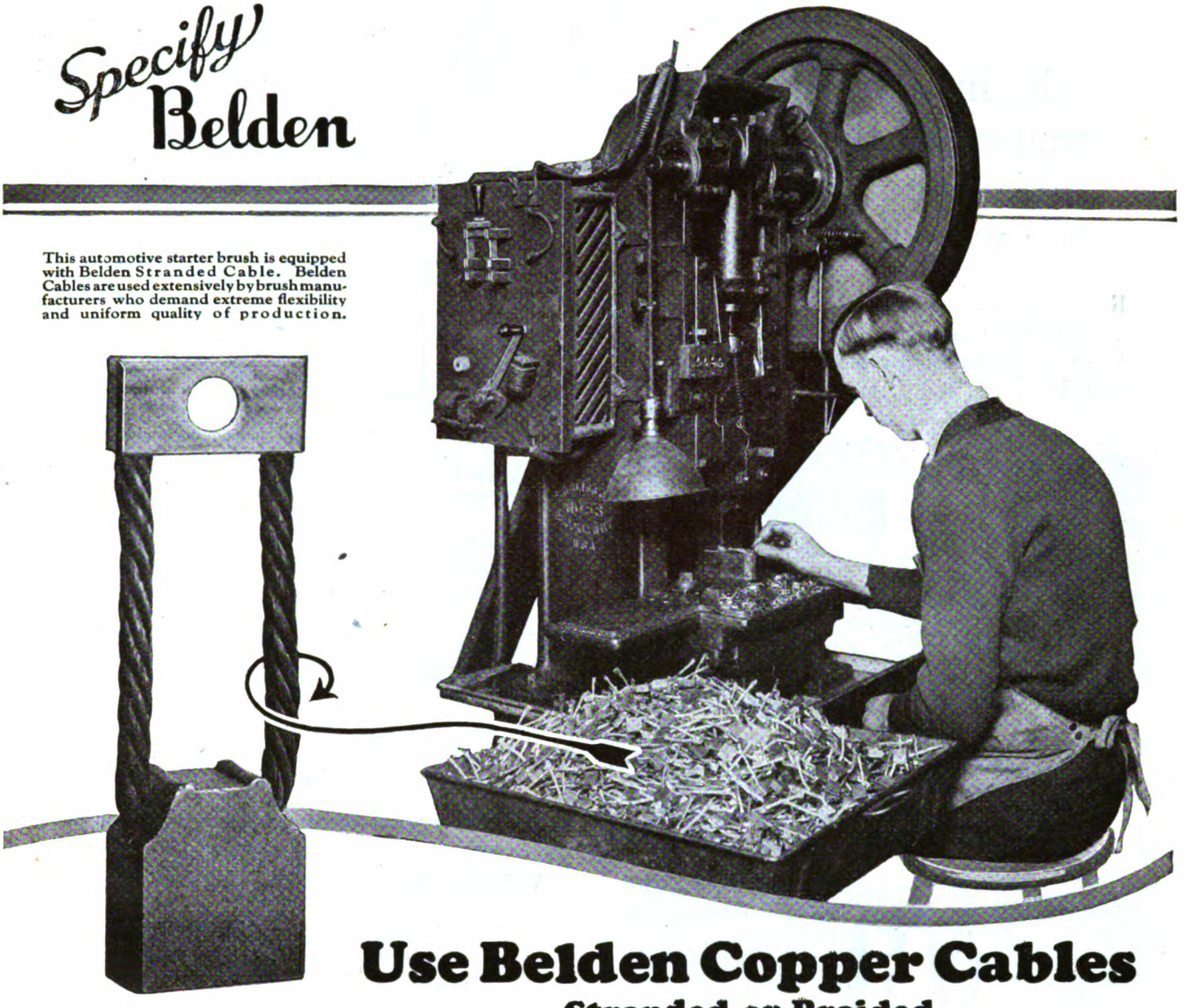
The highly desirable finish on Salamander wires and cables is only obtained by using long asbestos fibres. These fibres do not require a cotton thread as a carrier during the insulating process, thereby avoiding the tendency of opening.

The resulting Salamander insulation gives a smooth, hard, continuous wall.

York Insulated Wire Works
of General Electric Co.
York, Pa. 120 Broadway, N. Y. C.

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This automotive starter brush is equipped with Belden Stranded Cable. Belden Cables are used extensively by brush manufacturers who demand extreme flexibility and uniform quality of production.

Use Belden Copper Cables

Stranded or Braided
For SWITCHES—GENERATORS—MOTORS

BELDEN Copper Cables are made of soft annealed copper strands. The number of individual strands vary from 24 to over one thousand in a single cable, the larger number of strands being used for extreme flexibility.

Belden facilities for manufacturing these special cables are extensive and complete, and inquiries are solicited from manufacturers, electric railways, and other users of stranded and braided flexible cables. Complete specifications and prices will be furnished for any type of cable, on request.

Specify Belden Magnet Wire

Belden facilities for manufacturing magnet wire permit an output exceeding 200,000,000 feet of magnet wire each week. The entire manufacturing process from wire mill to enameling or insulating, is carried on in our own departments.

Beldenamel wire is extensively used, either with or without cotton insulation, for rewinding motors and generators. Our engineering data book on Beldenamel wire describes the uses and advantages of Beldenamel, Cotenamel, and Silkenamel, and contains interesting engineering curves and tables. Send for it, TODAY!

Mail the Coupon for Engineering Data

Belden Manufacturing Co.
2314B S. Western Ave.
Chicago, Illinois

Kindly send us descriptive literature on Belden flexible cables. Also enclose your engineering data on Beldenamel Magnet Wire.

Name .....

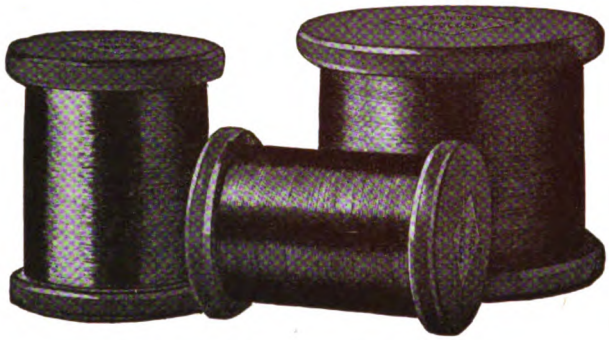
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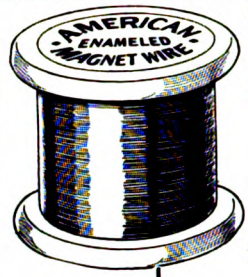
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The insulation makes all the difference in the world.

Repeated checking at every step in its manufacture assure you that Maring Wire is insulated for keeps. Send for sample.



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Put American Magnet Wire, enameled, cotton or silk insulation, to the test, just once, and you will see why industrial men who know always specify this wire. American Magnet Wire is always of uniform gauge.

The American Enameled Magnet Wire Co.,
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AMERICAN MAGNET WIRE
assures maximum service—finest results real economy

Order American Magnet Wire for your next requirements. You will standardize on it once you put it to the test. We will gladly send samples upon request.

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"OK" Weatherproof Wire
"Parac" Rubber Wire
Slow Burning Wire
Bare Copper Wire

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Plain Enamel, Single Cotton Enamel,
Single and Double Cotton Covered.

"AMERICAN BRAND"

Weather-proof Copper Wire and Cables
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Are representative of the highest principles in manufacturing and merchandising in the wire industry.

American Insulated Wire & Cable Co.
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Bleachers, Dyers and Mercerizers of Cotton Yarns and Warps
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Manufacturers of Cotton Yarns in Fast Colors
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"Sewing and Stitching Threads for All Industries"



Home of Silkslip Braider Thread
WORCESTER, MASS.

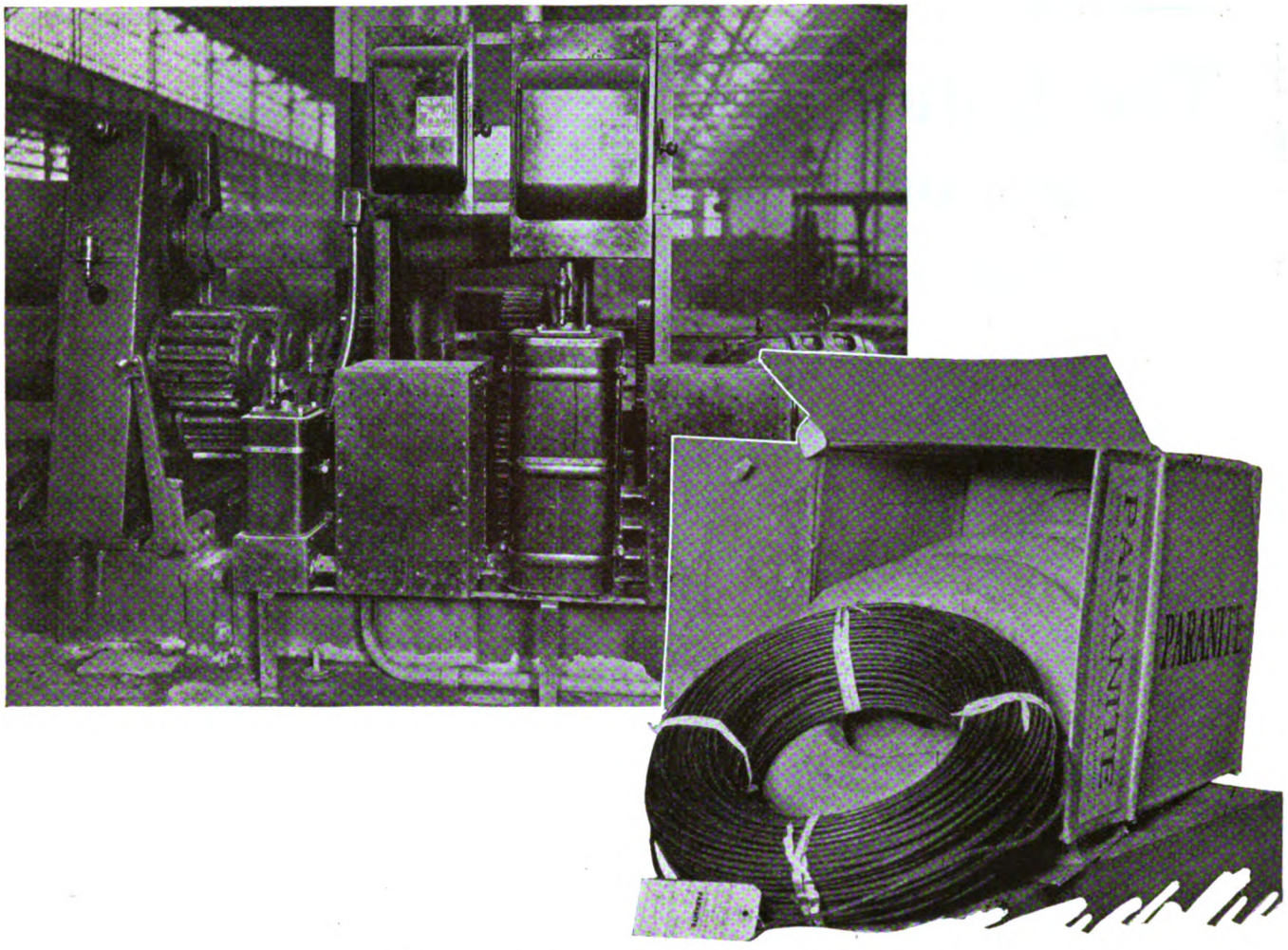
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Coil making machines offer the latest in modern equipment for coil making.
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Manufacturers
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Consider the Life of the Wire

Industry is depending more and more on PARANITE for wiring requirements.

The reasons are simply that PARANITE insulation contains a liberal allowance of rubber and is "better than code requires." Economy is always an outstanding result where PARANITE is used from handling to the finished job. Give quality full consideration and make certain that PARANITE is used in those next wiring jobs.

Let us send you PARANITE samples. We give prompt service at all times.

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Marquette Bldg., Chicago
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Walter I. Ferguson & Co.
208 Baltimore Bldg.
Kansas City, Mo.
Western Representative

If it's

PARANITE

it's right

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This Catalogue Sent on Request



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The new WIREMOLD CONDUIT SYSTEM CATALOGUE AND WIRING GUIDE which gives complete practical installation information for installing WIREMOLD on the various kinds of wall and ceiling construction will be gladly sent on request.

Wiremold is the established standard for surface wiring and is inexpensive to buy—easy to install and makes a sturdy good looking job.

Get acquainted with Wiremold Conduit and you'll be surprised of its advantages over old methods.

Approved by Underwriters Laboratories and Associated Factory Mutual Fire Insurance Companies—carried in stock by leading electrical jobbers.

The American Wiremold Co.,
Hartford, Conn.

Please send me catalogue and Wiremold Sample.
☐ Check here.

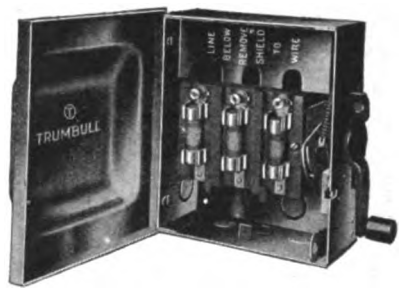
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"CIRCLE T" "R. M." TYPE SWITCHES for motors up to 7½ H. P.

Mr. Engineer:

Our "R.M." line of motor starting switches is the lowest priced line on the market which will give you the service required in the Industrial Plant.



No. 94321 (Fig. 1)

Fig. 1 shows the two position motor starting switch which short circuits the fuses while motor is accelerating. For motors up to 5 H.P.

Fig. 2 shows the "R.M." type with inverse time protective cutouts for motors up to 7½ H.P., 440-550 V.



No. 93361 (Fig. 2)



No. 92321 (Fig. 3)

Fig. 3 shows the fusible type for small motors which can be thrown directly on the line with fuses in circuit.

Circular No. 2 describes in full our complete line of Motor Starting Switches.

THE TRUMBULL ELECTRIC MFG. CO.
PLAINVILLE, CONN.

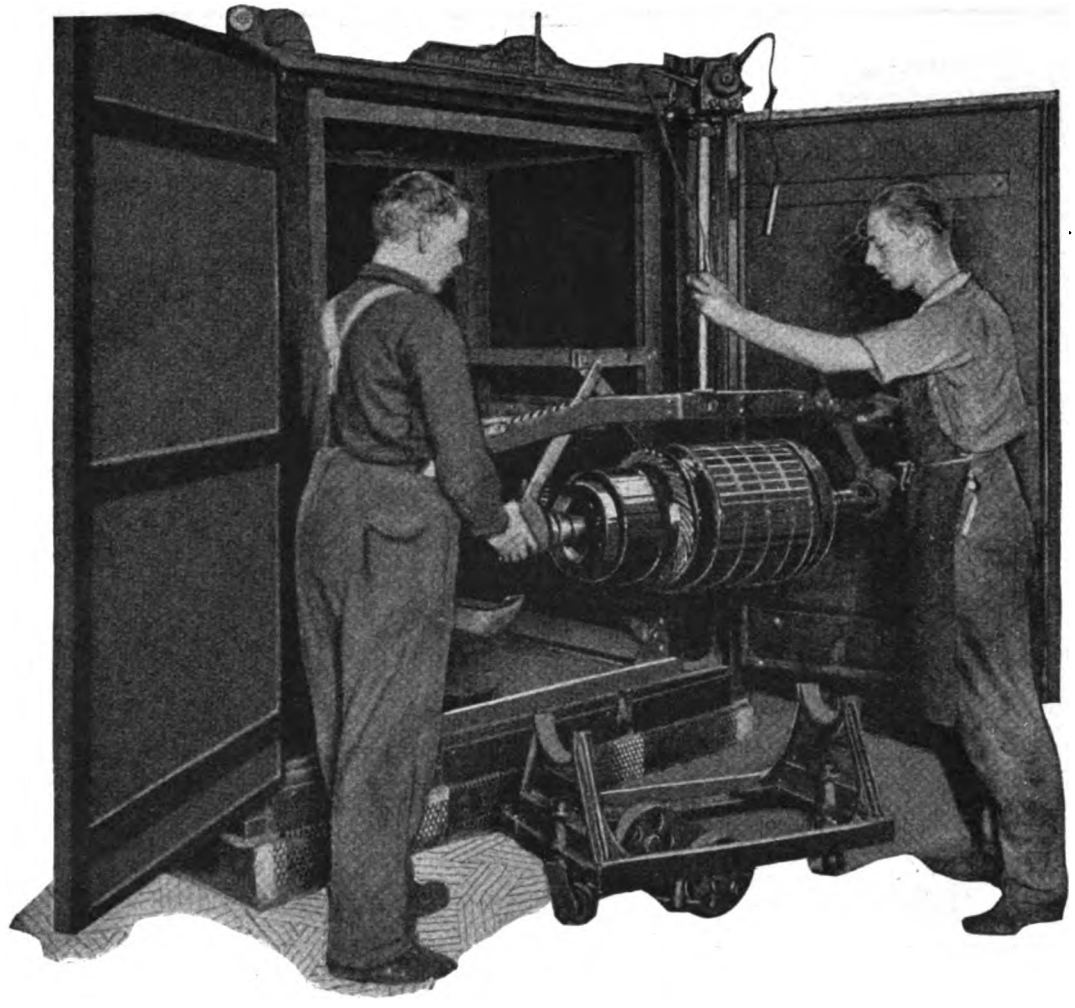
NEW YORK
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Armatures that bake longer last longer—

Thoroughness pays in overhauling armatures and coils, transformers, etc. A few hours added to the baking schedule will pay big dividends in longer life of the equipment.

"New fangled ideas" of doing just as good a job in less time with some fancy product that "somebody" has to sell will stand a thorough investigation. And an analysis will generally prove that instead of being better it is of poorer quality than claimed.

You can rest assured that in the twenty years since 1905 when Irvington started serving railways, mines and industrial plants, this company has looked after the best interests of its customers by constantly improving its product where it was possible.

Irvington Varnish & Insulator Co.
Irvington, N. J.

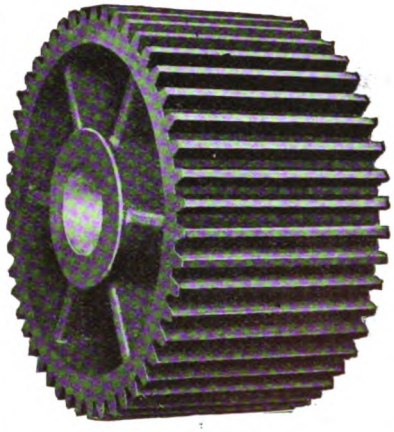
Sales Representatives:

Mitchell-Rand Mfg. Co., New York
T. C. White Electrical Supply Co., St. Louis
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Today the Irvington Varnish and Insulator Company is the largest producer in the World of flexible varnished insulation. The quality and performance of Irvington Products no longer rests on claims or theoretical tests but on the long practical experience of leaders in electrical industry who have specified "Irvington" consistently during the past twenty years.

Such established standards of quality constitute a real safeguard. Write for the Irvington Insulation Book.

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Ask your Master Mechanic this Question

If all the gears and pinions you broke or wore out last year had lasted four times as long, how much would you have been ahead today? Remember, Nuttall BP Gears are guaranteed to last four times as long as the ordinary kind.

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Nuttall







America's greatest producer of copper *conserves commutators with IMPERIAL Commutator Stones*



Immediate Delivery from Stock

This is one of the hundreds of huge industrial plants where Imperial Commutator Stones are effecting a saving of from three to twenty times their cost by keeping commutators in proper working condition, avoiding delays, shutdowns and expensive repairs.

To eliminate sparking, ridges, high bars, high mica or flat spots, use Imperial Commutator Stones regularly.

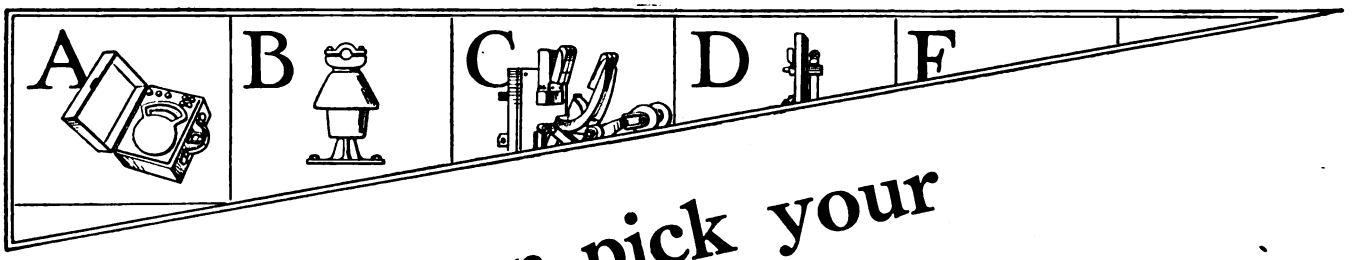
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Fill in and mail to receive free copy of new 16-page Catalog (No. 6).

MARTINDALE ELECTRIC CO., 11709 Detroit Ave., Cleveland, Ohio 2-25

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From A to Z*



You can pick your electrical supplies *out of this list*

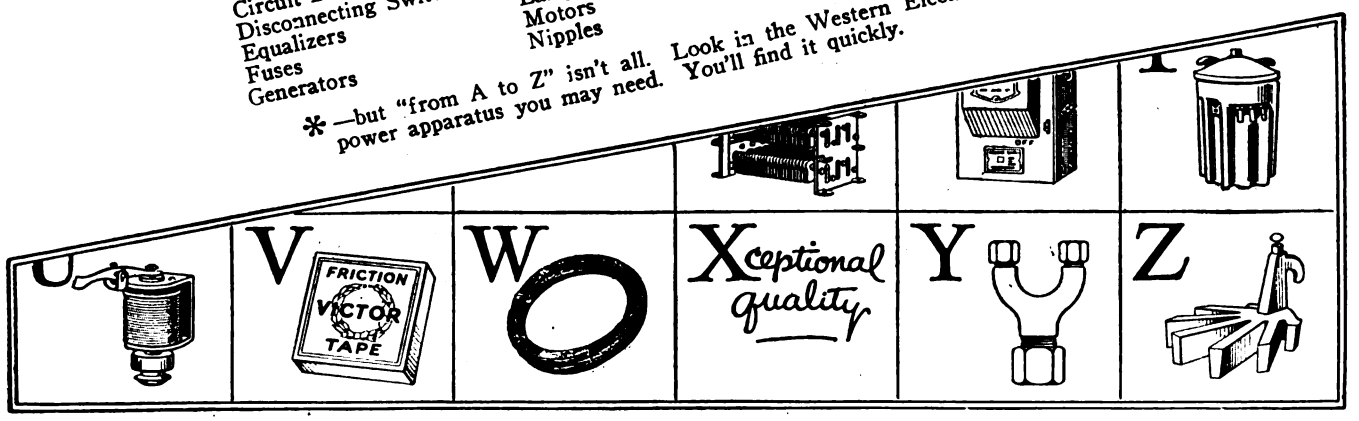
The man who buys power apparatus faces two questions: **"Where can I buy it?"** It may be a welcome fact to know that Western Electric stocks cover every power apparatus requirement from A to Z. The Western Electric Year Book, listing hundreds of items in simplified order, makes it possible to locate a desired power apparatus unit at a moment's notice.

"When can I get it?" No less important is the answer to this question—that Western Electric carries ready for immediate shipment large stocks of motors, control, switches, and other power apparatus. Quick delivery from a nearby distributing house is a big feature of Western Electric service.

And, of course, the biggest feature is that Western Electric supplies come to you with the indorsement of over half a century of electrical experience.

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Circuit Breakers
Disconnecting Switches
Equalizers
Fuses
Generators
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Junction Boxes
Knife Switches
Lamps
Motors
Nipples
Oiled Silk
Panels
Quick Delivery
Resistors
Square D Switches
Transformers
Undervoltage Attachments
Victor Tape
Wire
Xceptional Quality
Y—Connectors
Zincs, Battery

*—but "from A to Z" isn't all. Look in the Western Electric Year Book for whatever power apparatus you may need. You'll find it quickly.



Western Electric

QUALITY ELECTRICAL SUPPLIES

OFFICES IN 54 PRINCIPAL CITIES

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I. E.

POSITIONS VACANT

WANTED FIRST CLASS REPAIR MAN, capable of rewinding all classes electrical apparatus. Steady job. Young Electric Wks., Augusta, Ga.

BE A METER ENGINEER

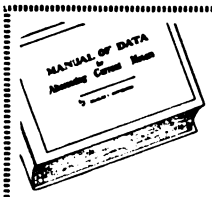
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Central stations must have Electrical Meter Engineers. They pay high salaries. Write today. Just your name and address on a postal and we will send you full particulars free. Ft. Wayne Correspondence School, Dept. 80, Ft. Wayne, Ind.

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1—General Electric D. C. Generator, 15 KW., 250 volts, type RC20, speed 1730, 60 amps., with pulley and base. Price....$285.00

1—General Electric D. C. motor, 5 H. P., 230 volts, type RC 27A, amps. 19.1, speed 1150. No pulley or base. Price..... 165.00

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A MANUAL OF WINDING DATA

A printed manual giving the actual rewinding data for two and three phase motors of twelve leading manufacturers. It contains actual data necessary to change the speed, phase, or horse power of A. C. Motors. Earns its cost quickly. We guarantee satisfaction or money refunded on return of manual. Ask for circular and samples.

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This National Electric Clearing-House

is THE "connecting link" between those anxious *to move* equipment and those who are looking for bargains. List "your condition" with

R. P. McCONAHAY, Van Wert, Ohio

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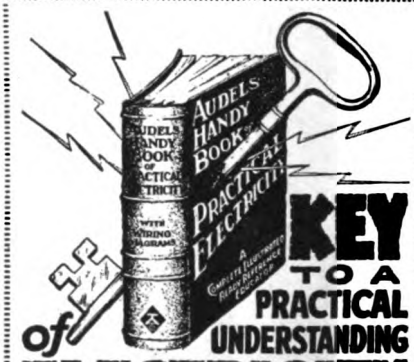
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Reconditioned Like New and Guaranteed
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A quick simplified ready reference, giving complete instruction and inside information. Handy to use. Easy to understand. For Engineers, Professional Electricians, Students and all interested in Electricity. A reliable authority and a handy helper for every electrical worker.

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The 1040 pages aand 2600 diagrams give accurate, up-to-date and complete information on—Rules and Laws, RADIO, Storage Batteries, WIRING DIAGRAMS, Power and House Wiring, Automatic 'Phones, Auto Ignition, Motor Troubles, ARMATURE WINDING, Cable Splicing, Elevators and Cranes, Sign Flashers, Transformers, Practical Management, Modern Applications—READY REFERENCE on every electrical subect. Pocket Size, handsomely bound in flexible Red LEATHER. Easy Terms. Shipped for Free Examination. No obligation to buy unless satisfied.

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The Searchlight Section of This Paper

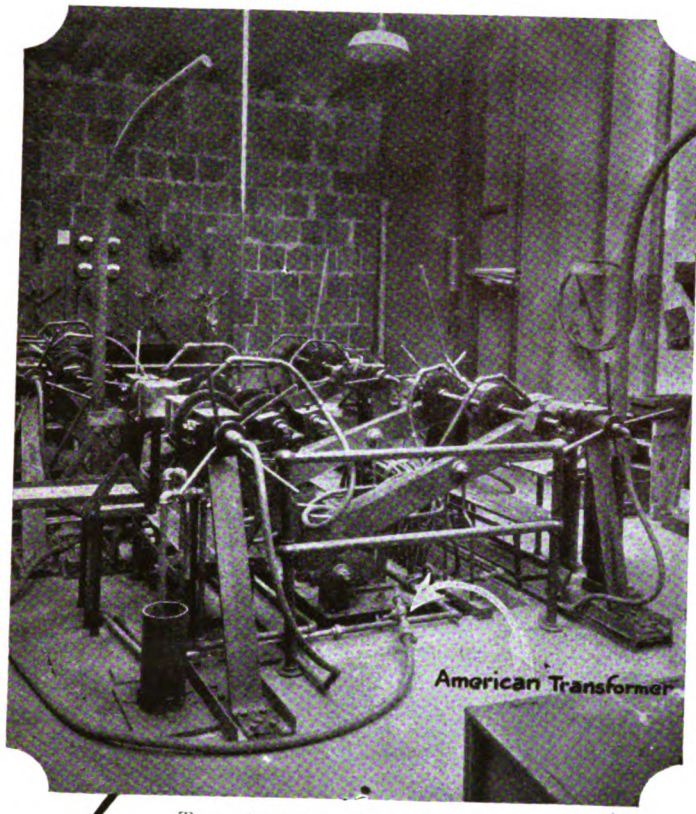
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Again, the Ultimate Solution!

When the Hermas Machine Co., Hawthorne, N. J., built the new hydraulically operated furnace illustrated the transformer problem involved was one embodying many conditions with which transformer manufacturers in general could not cope.

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In mills, foundries, and in general industrial plants all over the country there are American Transformers which are delivering the best of service and long uninterrupted operation in all kinds of work because they are correctly designed to meet the requirements of the particular process in which they are utilized.

Perhaps right at this minute you have a special problem that requires careful attention and involves economical utilization of power.

Whatever your needs, it will pay you to get the benefit of our experience. No obligation. Just address the company.

For your information we shall gladly send you Bulletins 1025 and 1030 which describe some of these transformers.

AMERICAN TRANSFORMER CO.
178 Emmet Street, Newark, N. J.

Transformers

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WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here.

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7 South Dearborn St. Chicago

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Allis-Chalmers Mfg. Co.

Air Filters
Midwest Air Filters, Inc.

Ammeters, Voltmeters
(See Instruments, Electrical.)

Armature Coil Spreaders
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Bearing Metal
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Elec. & Mfg. Co.

Belts, Conveyor
Link-Belt Co.

Belts, Transmission
Link-Belt Co.

Bleachers
Worcester Bleach & Dye Works Co.

Blocks, Pillow
Fafnir Bearing Co.

Blowers
Clements Mfg. Co
Electric Blower Co.
Green Equipment Corp.
Martindale Electric Co.

Bolts, Nuts and Screws
Sturtevant Co., B. F.

Books, Technical
Audel & Co., Theo.
McGraw-Hill Book Co., Inc.

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Boxes
Conduit
Appleton Electric Co.
Johns-Pratt Co.
Floor Outlet
Adam Electric Co., Frank
Hubbell, Inc., Harvey
Junction and Outlet
Appleton Electric Co.
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Meter and Service
General Electric Co.
Johns-Pratt Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Sectional, Switch & Outlet
Appleton Electric Co.

Brakes
Crane
Westinghouse Elec. & Mfg. Co.
Disc
Westinghouse Elec. & Mfg. Co.
Electric
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Brushes
Commutator
Baylis Co., The
Boxill-Bruel Carbon Co.
Calebaugh Self Lubricating Carbon Co.
Carbon Engineering Co.
Corliss Carbon Co.
General Electric Co.
Hohlman & Hill, Inc.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Elec. & Mfg. Co.
Controller
Corliss Carbon Co.
Dynamic and Carbon
Boxill-Bruel Carbon Co.
Corliss Carbon Co.
Hohlman & Hill, Inc.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Elec. & Mfg. Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Elec. & Mfg. Co.

Bus Bar Supports
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Bushings
Appleton Electric Co.
National Metal Molding Co.

Cables (See Wire & Cable)

Cable Accessories
Dossert & Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Carbon Brushes
(See Brushes.)

Castings, Steel
Falk Corp.

Cement
Commutator
Martindale Electric Co.

Chains, Power Transmission
American High Speed Chain Co.
Link-Belt Co.

Circuit Breakers
Condit Electrical Mfg. Co.
Cutler Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Clamps
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cleats
National Metal Molding Co.
Square D Co.

Cloth Wipers
Aaron Ferer & Sons

Clutches
Friction
Allis-Chalmers Mfg. Co.
Link-Belt Co.
Magnetic
Cutler-Hammer Mfg. Co.

Coal and Ash Handling Equipment
Link-Belt Co.

Coatings, Preservative
Sterling Varnish Co.

Coil Winding Machines
Armature Coil Equipment Co.
Belden Mfg. Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coils, Choke
American Transformer Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Coils, Induction
American Transformer Co.

Coils, Magnet, Field
Belden Mfg. Co.

Compensators
Automatic
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduits
American Circular Loom Co.
American Wiremold Co.
National Metal Molding Co.
Tubular Woven Fabric Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 92.

Connectors & Terminals
Belden Mfg. Co.
Dossert & Co.
General Electric Co.
Ohio Electric & Controller Co.
Westinghouse Elec. & Mfg. Co.

Contacts, Carbon & Metal Graphite
Corliss Carbon Co.

Control Systems
Monitor Controller Co.

Controller Fingers
Russell Mfg. Co.

Controller Regulators
Monitor Controller Co.

Controllers
Automatic
Allen-Bradley Co.
Industrial Controller Co.
Lewellen Mfg. Co.
General Electric Co.
Johns-Pratt Co.
Westinghouse Elec. & Mfg. Co.
Motor
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Sundh Electric Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Rheostatic
Monitor Controller Co.
Speed
Monitor Controller Co.

Conveyers
Link-Belt Co.
Weller Mfg. Co.

Conveyors, Gravity
Standard Conveyor Co.

Cooling Air Filters
Midwest Air Filters, Inc.

Cord, Flexible
Belden Mfg. Co.
Hubbell, Inc., Harvey
Okonite Co., The
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Cotton Yarns
Worcester Bleach & Dye Works Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Dodge Mfg. Co.
Falk Corp.
Foote Bros., Gear and Machine Co.
Nuttall Co., R. D.
Smith & Serrell

Crane Controllers
Monitor Controller Co.

Crane Motors
Monitor Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Cranes, Portable Electric
Elwell-Parker Co.

Cross Arms
Electric Service Supplies Co.
Western Electric Co.

Cutouts
General Electric Co.
Hubbell, Inc., Harvey
Johns-Pratt Co.
Square D Co.
Trumbull Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Cutters
Hole
Koch & Co., Paul W.
Commutator Slotting
Hullhorst Micro Tool Co.

Diagrams, Winding
Chittenden, Charles L.
McGraw-Hill Book Co., Inc.

Silent Chain
American High Speed Chain Co.
Link-Belt Co.

Dynamos
(See Generators & Motors.)

Electric Lighting
Benjamin Elect. Mfg. Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Elevators & Conveyors
Link-Belt Co.
Weller Mfg. Co.

Enamels, Wire, Weed and Steel
Impervious Varnish Co.
Sterling Varnish Co.

Engineers, Illuminating
Westinghouse Elec. & Mfg. Co.

Engines Oil
Allis-Chalmers Mfg. Co.
Fairbanks-Morse & Co.
Falk Corp.

Factory Furniture
Westinghouse Elec. & Mfg. Co.

Factory and Mill Lighting
Westinghouse Elec. & Mfg. Co.

Fan Hangers, Electric
Adam Electric Co., Frank

Fan Motors
Century Electric Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Fans
Exhaust and Ventilating
Century Electric Co.
General Electric Co.
National Screw & Mfg. Co.
Star Electric Motor Co.
Westinghouse Elec. & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Filters, Air
Midwest Air Filters, Inc.

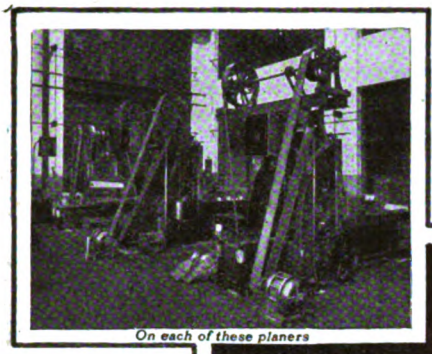
Fittings
Conduit
Appleton Electric Co.
National Metal Molding Co.
Pipe
Westinghouse Elec. & Mfg. Co.

Fixtures, Lighting
American Fixture Co.
McGill Mfg. Co.
Westinghouse Elec. & Mfg. Co.

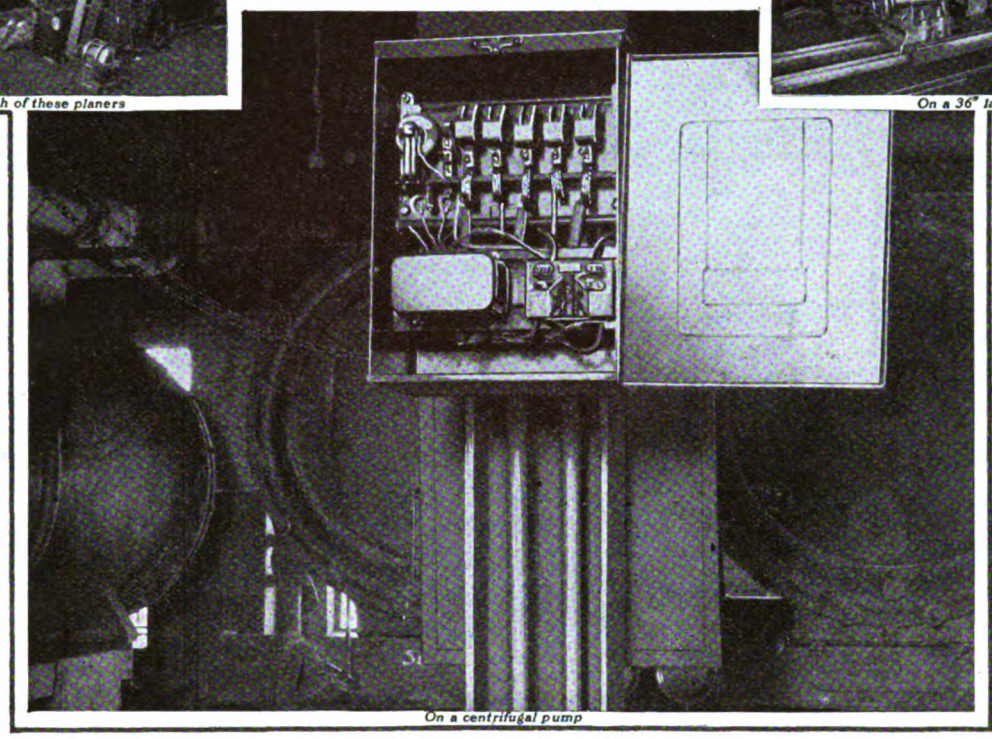
Furnaces, Electric
General Electric Co.
Westinghouse Elec. & Mfg. Co.

(Continued on page 88)

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On each of these planers


On a 36" lathe


On a centrifugal pump

Why This G-E Automatic Compensator is Popular

The CR7051-J1 Automatic Compensator for Squirrel Cage Induction Motors continues to gain favor. There are four outstanding reasons:

The Definite Time Accelerating Relay, which gets the motor on the line in the quickest possible time.

The Multiple Rated Auto Transformer applied for the first time by General Electric on a standard Compensator.

The unique method of mounting the starting and running contactors, providing ample access to both for inspection and replacement of parts, at the same time maintaining ease of installation.

The Temperature Overload Relay.

Shown above are four of 40 which the American Can Co. has installed on various machine tools; also one at the Warner Sugar Refining Co., which has been operating for 18 months in an atmosphere charged with salt, pulverized carbon, and lime.

The Industrial Control Specialist in your nearest G-E office can give you additional reasons for the popularity of this and other G-E Control Devices.

General Electric builds a type of control for every motor application. Each device has built into it the experience accumulated in the manufacture of all types of motors and control for more than 30 years.

9-18

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES

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"What & Where to Buy"

(Continued from page 86)

Fuse Clips
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Westinghouse Elec. & Mfg. Co.

Fuses
General Electric Co.
Mfg. Co.
Johns-Pratt Co.
Trico Fuse Mfg. Co.
Renewable
Bussman Mfg. Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.
Johns-Pratt Co.

Gears
Dodge Mfg. Corp.
Falk Corp.
Foote Bros. Gear and Machine Co.
Link-Belt Co.
General Electric Co.
Nuttall Co., R. D.
Smith, Winfield H.
Westinghouse Elec. & Mfg. Co.
Composition
Chicago Rawhide Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Generating Sets
Allis-Chalmers Mfg. Co.
Crocker-Wheeler Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Generators
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Chandeysson Electric Co.
Crocker-Wheeler Co.
Electro-Dynamic Co.
General Electric Co.
Hertner Electric Co.
Reliance Elec. & Eng. Co.
Star Electric Motor Co.
Westinghouse Elec. & Mfg. Co.

Glue Pots
Westinghouse Elec. & Mfg. Co.

Grinders
Chicago Pneu. Tool Co.
Fafnir Bearing Co.
Martindale Electric Co.

Grounding Devices
Dossert & Co.

Hammers
Pneumatic
Chicago Pneu. Tool Co.
Rawhide
Chicago Rawhide Mfg. Co.

Hangers, Line Shaft
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.

Hangers, Safety, Disconnecting
Thompson Electric Co.

Heating Devices, Industrial
Campbell Mfg. Co.
General Electric Co.
Midwest Air Filters, Inc.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Hoists, Electric
General Electric Co.
Link-Belt Co.

Indicators, Speed
(See Tachometers.)

Instrument Transformers
American Transformer Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Instruments, Electrical
Graphic
Esterline-Angus Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Roller-Smith Co.
Taylor Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Corp.
Integrating
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Scientific and Testing Service
Biddle, James G.
Esterline-Angus Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Corp.

Insulating Material
Comp. Cloth and Paper
Belden Mfg. Co.
General Electric Co.
Sterling Varnish Co.
Westinghouse Elec. & Mfg. Co.
Compounds, Paints and Varnishes
Belden Mfg. Co.
Dolph Co., John C.
General Electric Co.
Impervious Varnish Co.
Irvington Varnish & Ins. Co.
Martindale Electric Co.
Sterling Varnish Co.
Westinghouse Elec. & Mfg. Co.
Fibre
General Electric Co.
Molded
Belden Mfg. Co.
Cutler-Hammer Mfg. Co.
Tape and Webbing
Anchor Webbing Co.
General Electric Co.
Okonite Co., The
U. S. Rubber Co.
Westinghouse Elec. & Mfg. Co.

Insulators
Electric Service Supplies Co.
General Electric Co.
Irvington Varnish & Ins. Co.
Square D Co.
Westinghouse Elec. & Mfg. Co.

Lamp Guards
Electric Service Supplies Co.
Hubbell, Inc., Harvey
Morse Co., Frank W.
Westinghouse Elec. & Mfg. Co.

Lamps
Arc
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Incandescent
General Electric Co.
Western Electric Co.
Nitrogen
Westinghouse Elec. & Mfg Co.
Trouble
Benjamin Elect. Mfg. Co.

Lighting, Industrial
American Fixture Co.
Benjamin Elect. Mfg. Co.
General Electric Co.
Morse Co., Frank W.
Natl. Screw & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Lightning Arresters
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Line Material
Electric Service Supplies Co.
General Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Magnetic Separators
Electric Controller & Mfg. Co.

Magnets
Cutler-Hammer Mfg. Co.

Mallets, Composition
Miller Rubber Co. of N. Y.

Material Handling Equipment
Link-Belt Co.
Weller Mfg. Co.

Metal Stampings
American Pulley Co.

Meters
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Meter Testers
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Mica Under Cutting Machines
Hullhorst Micro Tool Co.

Molding, Metal
National Metal Molding Co.

Motors
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Baldor Electric Co.
Burke Electric Co.
Century Electric Co.
Chandeysson Electric Co.
Crocker-Wheeler Co.
Electro-Dynamic Co.
General Electric Co.
Hertner Electric Co.
Jeannin Electric Co.
Lincoln Electric Co.
Marble-Card Electric Co.
Master Electric Co.
Natl. Screw & Mfg. Co.
Reliance Electric & Eng. Co.
Star Electric Motor Co.
Sturtevant Co., B. F.
Valley Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Motor Generators
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Crocker-Wheeler Co.
Hertner Electric Co.
Reliance Elec. & Engr. Co.
Westinghouse Elec. & Mfg. Co.

Motor Generator Chargers
Ohio Electric & Controller Co.

Oil Cups
Gits Brothers Mfg. Co.

Oil Gages
Gits Brothers Mfg. Co.

Outlets
American Wiremold Co.

Ovens, Electric
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Overhead Layout Anchorage
Midwest Steel & Supply Co.

Panel Boards
Adam Electric Co., Frank
Benjamin Elect. Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Panel Board Fittings
Chicago Fuse Mfg. Co.

Panels, Switchboard
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Pinions
Foote Bros., Gear and Machine Co.

Pipe Benders
Appleton Electric Co.

Plugs
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Westinghouse Elec. & Mfg. Co.
Attachment
Hubbell, Inc., Harvey

Potentiometers
Biddle, James G.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Power Transmission Appliances
Allis-Chalmers Mfg. Co.
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Lewellen Mfg. Co.
Link-Belt Co.
Nuttall Co., R. D.
Reeves Pulley Co.
Weller Mfg. Co.

Projectors, Floodlighting
Electric Service Supplies Co.
Westinghouse Elec. & Mfg. Co.

Protective Devices
Condit Elec. Mfg. Co.
General Elec. Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Pulleys
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.
Reeves Pulley Co.
Smith, Winfield H.

Pulling Tools
Premier Electric Co.

Pull Sockets
Hubbell, Inc., Harvey

Pumps
Centrifugal
Allis-Chalmers Mfg. Co.
Reciprocating
Allis-Chalmers Mfg. Co.

Racks, Machine
Foote Bros. Gear and Mach. Co.

Recorders, Temperature & Pressure
Taylor Instrument Co.

Rectifiers
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Reels, Extension
Appleton Electric Co.

Reflector Hangers
Safety Disconnecting
Thompson Electric Co.

Reflectors
Hubbell, Inc., Harvey
Thompson Electric Co.
Westinghouse Elec. & Mfg. Co.

Regulators
Induction Voltage
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Speed
Cutler-Hammer Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Temperature and Pressure
Electric Controller & Mfg. Co.
Taylor Instrument Co.

Relays, Overload
Allen-Bradley Co.

Repair Data
McGraw-Hill Book Co., Inc.

Resistance Units
General Electric Co.
Monitor Controller Co.
Westinghouse Elec. & Mfg. Co.

Rheostats
Allen-Bradley Co.
Biddle, J. G.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Rivets
Hubbell, Inc., Harvey

Rosettes
Hubbell, Inc., Harvey
National Metal Molding Co.

Sanders
Nichols-Lintern Co., The

Schools
Ft. Wayne Correspondence School

Screws, Machine
Hubbell, Inc., Harvey

Searchlights
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Second-Hand Apparatus
(See Searchlight Section)
Gregory Electric Co.

Shapes, Pressed Steel
American Pulley Co.

Signals
Indicating
Nichols-Lintern Co., The
Industrial
Benjamin Elect. Mfg. Co.

Silent Chain Drives
Link-Belt Co.

Slot Cleaning Tools, Commutator
Martindale Electric Co.

Slotters, Commutator
Green Equipment Corp.
Hullhorst Micro Tool Co.
Martindale Electric Co.

Sockets and Receptacles
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Westinghouse Elec. & Mfg. Co.

Solder
Allen Co., L. B.
Westinghouse Elec. & Mfg. Co.

Soldering Compounds
Allen Co., L. B.

Space Heaters
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Wiegand Co., Edwin L.

Speed Reducers
Falk Corp.
Foote Bros. Gear & Mach. Co.

Starters, Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Monitor Controller Co.
Square D Co.
Sundh Electric Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Stones, Commutator
Green Equipment Corp.
Martindale Electric Co.

Stop Signals
Nichols-Lintern Co., The

Strip Heaters
Westinghouse Elec. & Mfg. Co.
Wiegand Co., Edwin L.

Stringers, Steel
Midwest Steel & Supply Co.

Substations, Outdoor
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Supplies, Electrical
Flower, D. B.
Green Equipment Corp.
General Electric Co.
Hubbell, Inc., Harvey
Weeks, Arthur B.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

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For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 92.

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Keep Your Motors Running

Prevent Burnouts and Costly Shutdowns

THE new Cutler-Hammer "X" Starters keep the motors running—prevent production delays.

Aside from their long life construction—the *thermal* overload protection allows the motor that is thrown across the line sufficient excess current to accelerate properly. A rise in current does not necessarily cause the motor to be disconnected.

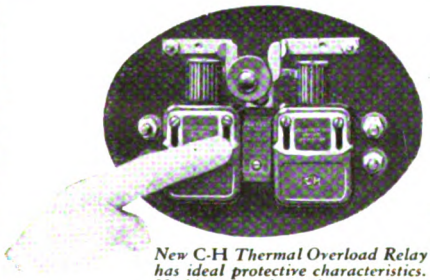
But, if the overload during starting or when running maintains long enough to cause serious overheating of the motor windings—then (before damage occurs) the motor will be disconnected.

Two safeguards against delays

First—the motor is not unnecessarily and frequently cut off from the line.

Second—burned-out motor windings are prevented—thus eliminating replacement of motor and expense of re-winding.

A few in stock will take care of the requirements for a wide range of motors from ¼ hp. up to 7½, 10 and 15 hp. depending upon the voltage and type of motor. By simply using the Thermal Cutout of proper rating for the 9585 Starter, or the proper relay heater coil for the 9586, the one starter is suitable for use with motors of various sizes. Let us mail you our new publication No. C-25.



New C-H Thermal Overload Relay has ideal protective characteristics. Nothing to replace after tripping—simply press the reset button. Adjustable to individual motor loads, giving exceptionally wide application.

THE CUTLER-HAMMER MFG. CO.

Works: Milwaukee and New York

Branch Offices:

New York: 8 W. 40th Street
Chicago: 323 N. Michigan Ave.
Pittsburgh: Century Bldg.
Philadelphia: Com'wealth Bldg.
Cleveland: Guardian Bldg.
Boston: 52 Chauncy Street
Detroit: 506 Hofman Bldg.
St. Louis: 2111 Ry. Exch. Bldg.
Buffalo: 358 Ellicott Sq. Bldg.
Milwaukee: 530 Grand Avenue
Cincinnati: 415 Dixie Terminal Building

Inquiries from the Pacific Coast may be directed to the H. B. Squires Co., Los Angeles, San Francisco, Portland, Seattle

Northern Electric Co., Ltd., Canada

CUTLER-HAMMER

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"What & Where to Buy"

(Continued from page 88)

Supplies, Railway
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Switchboard Supplies
Adam Electric Co., Frank
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Switchboards
Adam Electric Co., Frank.
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Condit Electric Mfg. Co.
General Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Battery Charging
Allen-Bradley Co.

Crane
Westinghouse Elec. & Mfg. Co.

Switch Board Fittings
Chicago Fuse Mfg. Co.

Switches

Air Brake and Pole Top
Condit Electrical Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Automatic
Allen-Bradley Co.
Industrial Controller Co.
Monitor Controller Co.
Sundh Electric Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Disconnecting
Electric Service Supplies Co.
General Electric Co.
Industrial Controller Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Electric Cutout
Chicago Fuse Mfg. Co.

Float
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Fuse
Adam Electric Co., Frank.
Condit Electrical Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Knife
Adam Electric Co., Frank.
Condit Electrical Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Magnetic
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Oil
Allen-Bradley Co.
Condit Electrical Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Remote Control
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Safety Enclosed
Adam Electric Co., Frank.
General Electric Co.
Johns-Pratt Co.
Square D Co.
Trumbull Electric Mfg. Co.
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Okonite Co., The
Tubular Woven Fabric Co.

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American Enameled Magnet Wire Co.
Belden Mfg. Co.
Maring Wire Co.
Rome Wire Co.
Western Electric Co.
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Belden Mfg. Co.
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Rome Wire Co.
Simplex Wire & Cable Co.
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American Steel & Wire Co.

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Indiana Rubber & Insulated Wire Co.
National Metal Molding Co.
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Considering the limited purchasing power of the average two dollar bill, it may seem hard to believe that a year of comprehensive assistance to the operating-maintenance man costs but $2.00.

Yet that is the price of a year's subscription to the Industrial Engineer—$3.00 for two years. (If this blank is used.)

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Address_____

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Title (or position)_____

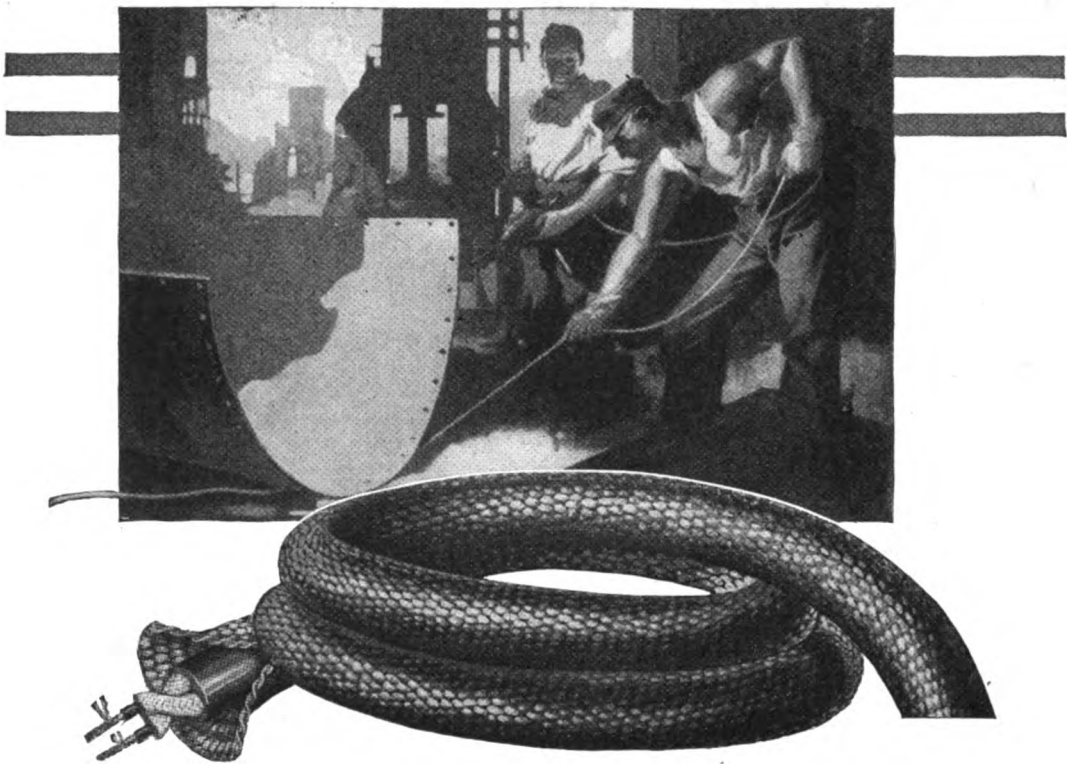
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No Job Is Too Hard for Duracord

Every part of DURACORD has ample strength to stand the hard knocks of everyday service.

Its conductors are composed of fine strands of pure copper—they help make DURACORD extremely flexible.

DURACORD

REG. U.S. PAT. OFF.

The DURACORD cover is woven parallel to the conductors. It resists jerks and pulls and prevents the copper stretching and breaking inside the cord.

Check up with your maintenance man on the number of breakdowns caused by conductors stretching. You'll find they form a large portion of your cord troubles.

If DURACORD did nothing but rid your plant of this trouble, you would be justified in putting it on the job.

Ask your Electrical Supply Jobber for a trial order of DURACORD! Test it out! You'll find it costs less per month of service.

TUBULAR WOVEN FABRIC CO.

PAWTUCKET, R. I.

Makers of

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DURAFLEX—Armored Cable.
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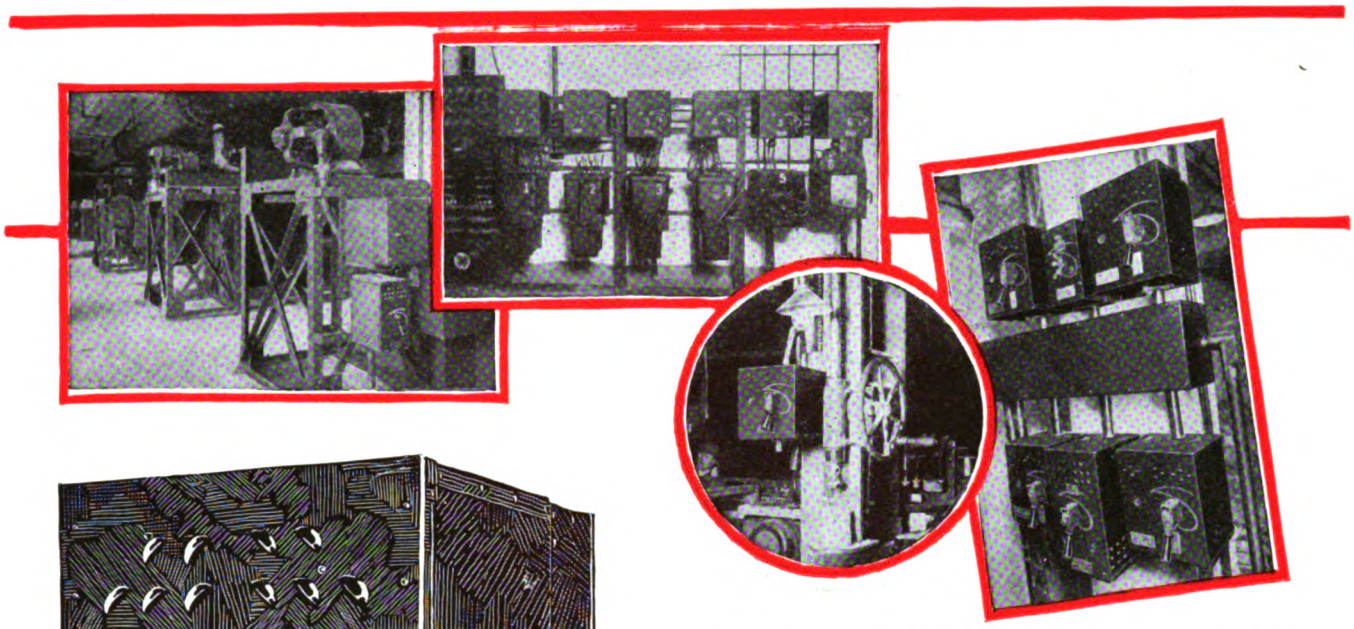
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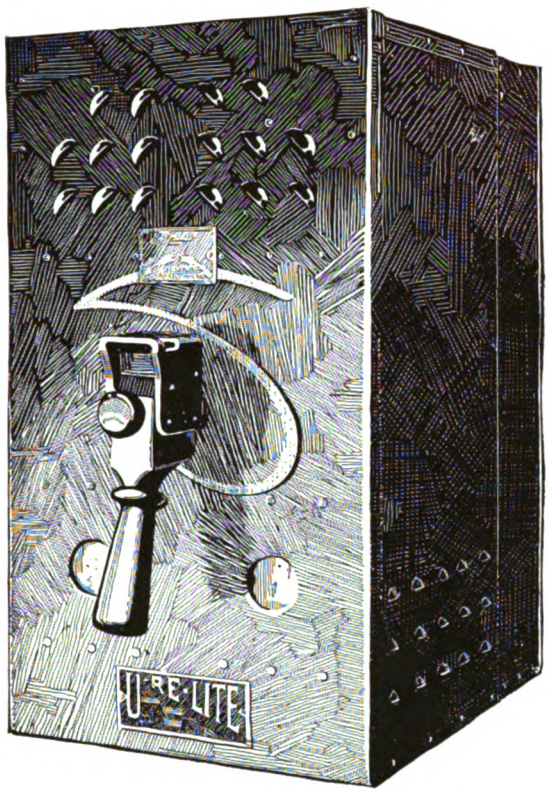
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"FOOL-PROOF PROTECTION" is not merely an idle statement—it is an *important Cutter fact.* Cutter Engineers designed U-Re-Lite to give *just such* protection to lighting and power circuits and electrical equipment by opening the circuit in the event of overloads or *short circuits.* U-Re-Lite does what fused switches and overload relays are *supposed* to do, but it does it without any expense.

It is fool-proof because it cannot be tampered with, once it is set and its protecting case is locked by the man in charge. You can't defeat its purpose by even *holding* the handle against an overload or short circuit. The switch members trip out just the same, and your valuable motors and other equipment are *permanently* safe. No fuses are necessary in the circuit.

A simple twist of the handle ON THE FRONT of the box resets U-Re-Lite after it has been tripped open.

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is The "I-T-E Circuit Breaker in the Steel Box." Thirty-six years of wide electrical experience has been built into U-Re-Lite. It can't go wrong because it's CUTTER-made.

U-Re-Lite prevents loss of time and money due to blown-out fuses and it keeps production losses down to a minimum. It eliminates all fuses and renewal parts and lasts a lifetime with no upkeep cost.

Cutter Engineers have set down their most valuable knowledge on Electrical Protection—based on 36 years of wide engineering and manufacturing experience—into a fully illustrated, bound HANDBOOK that every industrial executive and plant engineer should have in his possession. It is yours for the asking.

THE CUTTER COMPANY
ESTABLISHED 1888 — PHILADELPHIA
1824 Hamilton Street

I-T-E

This is probably the best-known and most valuable trade-mark in the electrical field. I-T-E on Circuit Breakers spells "36 years of Cutter Dependability in Electrical Protection." It protects you against inferior circuit breakers in the same way as does "U-Re-Lite."

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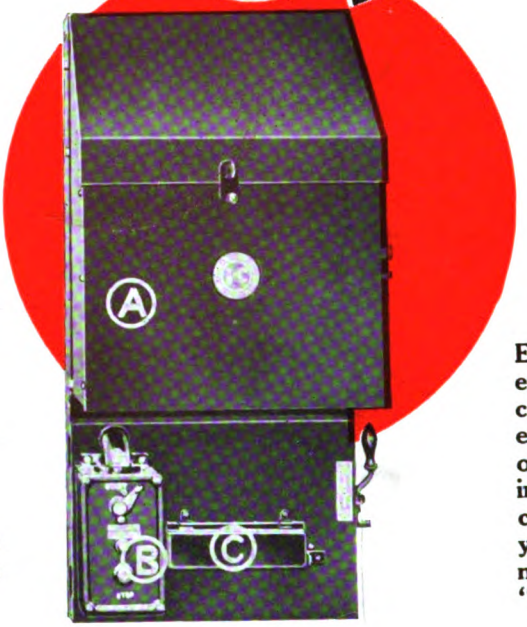
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It's the I-C way



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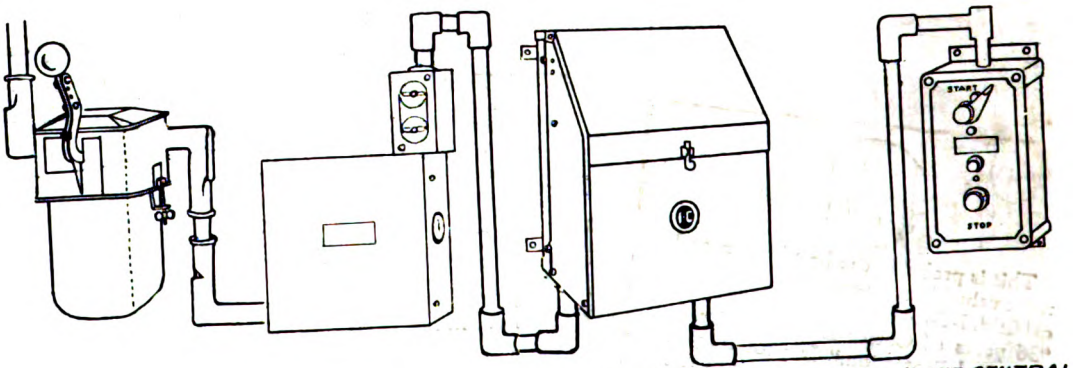
B—The Control Station

C—The Motor Service Switch and Test Jack Combined.

Class 8605-2400

Each part is a masterpiece, each simple in design and construction, each capable of easy installation, each part of each section standard and interchangeable—and such a compact unit! Let us tell you of the big Detroit automobile plants equipped with "IC" Automatics.

Here is what it eliminates-the old way



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